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Recent Revetment Construction on the Lower Mississippi River.

By CLARKE S. SMITH.*

The revetment just completed for bank protection at Panther Forrest, Ark., on the Mississippi River, about 451 miles below Cairo, furnishes an example of the construction now being used on the section of the river between the mouth of the Arkansas and Vicksburg rivers.

The revetment was necessary on account of the active caving which had been progressing in the concave bank of the bend at Panther Forrest for some years past, and particularly during the preceding season. The caving bank was thus gradually encroaching on the levee system at this point, and in anticipation of the time when the levee would be breached by further caving a new levee loop 3,200 ft. long had been constructed back about 1,000 ft. from the most exposed point. The continued erosion of the bank rendered additional work necessary, but to have constructed a longer loop still further back would have involved a large expenditure, owing to the topographical features of the ground along a new location. A new levee would necessarily have crossed an old bed of the Mississippi River, which seems to be an extension of what is now Lake Mason. It was decided to construct a revetment on this account as well as to obtain such improvement of the channel as would be produced by a discontinuation of the erosion of the bank, of the coincident deposit of sediment and of the formation of bars.

At the upper end of the proposed work a pocket had been eroded in the bank which was full of standing trees and snags. It was necessary to remove these obstructions before further work could be begun, and for this purpose the services of the government snagboats "John R. Macomb" and "Ben Humphries" were utilized. These are steel hull boats specially designed to carry on snagging operations in the Mississippi and Yazoo Rivers.

Two channel mats each 250 ft. wide and 1,010 ft. and 1,027 ft. long, respectively, were built and successfully sunk in place. The mats were constructed in the usual manner by binding willow brush into facines, by wiring the facines together in a single layer with their lengths approximately perpendicular to the bank and by attaching the necessary poles for framing, strengthening and holding the ballast.

As the building of a mat progressed it was gradually pushed off from the construction barges so that when it was completed it floated on the water and was held in place by the mooring barges at the upstream end and by cables fastened to the shore.

The sinking of the upstream channel mat is illustrated in the accompanying half-tone. The barges in the distance are over the upstream end of the mat, the laborers are throwing rock from the barges onto the mat, and as the latter sinks the rock barges are gradually drawn towards the downstream end by cables leading to a steamboat. The sinking is gradual, the upstream end reaching the bottom of the river while the downstream end is still afloat.

The depth of the water at the outshore edges of the channel mats during construction and sinking was as much as 45 ft. plus the stage of the river, which varied between 3 and 18 ft. Between extreme high and low waters the river at this place varies between stages of less than zero and more than 50 ft.

Three connecting mats were built between the inshore edge of the channel mats and the water line at the time of construction. These mats have the facines parallel to the general direction of the shore and fit into its irregularities on the one side and lap over the channel mats slightly on the other side.

The upper bank was graded to a uniform slope of about 1 on 4 and was paved with a layer of rock over a bed of spalls. The hydraulic method of grading was employed, and the grader is shown near the bank in the photograph. A new hydraulic grader was completed during the past season, its interesting feature being a steam turbine pump. This unit consists of a 36-in. 7-stage steam-turbine of the bucket and nozzle impulse type capable of developing 225 B. HP. at 1,300 r. p. m., and a direct-connected 3-stage centrifugal pump rated at 1,200 gals. per min. at 470 ft. total head. A surface condenser is used with the turbine, and steam is generated in three horizontal boilers of the usual Mississippi River type.

At this revetment two steamboats also used in connection with other work in progress were employed together with two mooring barges for holding the channel mats, quarter boats for boarding and lodging employees, and material barges for supplying willow brush and stone. The willow brush was furnished by contract at $1.45 per cord; stone was quarried and cost about $2.25 per cu. yd. on barges; labor cost from $1 to $1.25 per day of 8 hours, plus subsistence not exceeding 50 cts. per day and lodging; making a total of about $37 per lineal foot of bank protected. This total may be divided as follows: material 62%, payroll 25%, subsistence 8%, and miscellaneous 5%.

A work of this character is expensive and consequently can generally be placed only at critical points of the river where further erosion would cause great damage or involve other constructions of greater cost. The revetment with the necessary repairs from year to year may be considered permanent within a limit and effective in holding the bank in a stable condition and preventing further erosion and caving.

The Panther Forrest revetment is located in the Third District, Improving Mississippi River. Similar revetments to the one described at two other bends along the river, together with the necessary repairs to existing works, were made in this district during the past season.

MAT CONSTRUCTION AT PANTHER FORREST, ARK., ON THE MISSISSIPPI RIVER.
(View looking upstream. Mat completed and in process of being sunk.)

*Captain, Corps of Engineers, U. S. Army, Vicksburg, Miss.

Reinforced-Concrete Buildings for a Large Manufacturing Plant.

By W. A. HOYT.*

At Argo, Ill., a new industrial town about 12 miles west from Chicago, the Corn Products Refining Co. is building a new and modern plant. The buildings have cast-iron columns and steel framing, but in these the columns are not cased with concrete.

All warehouses and the simpler manufacturing buildings are of reinforced concrete throughout. The high and more complicated buildings, containing heavy process tanks and machinery, are of steel frame construction, the steel in most cases being encased in concrete, as noted. All buildings have the external appearance of concrete, there being no brick whatever used, and tile only rarely for partition walls. The external concrete was not given any special treatment for appearance. It was merely rubbed

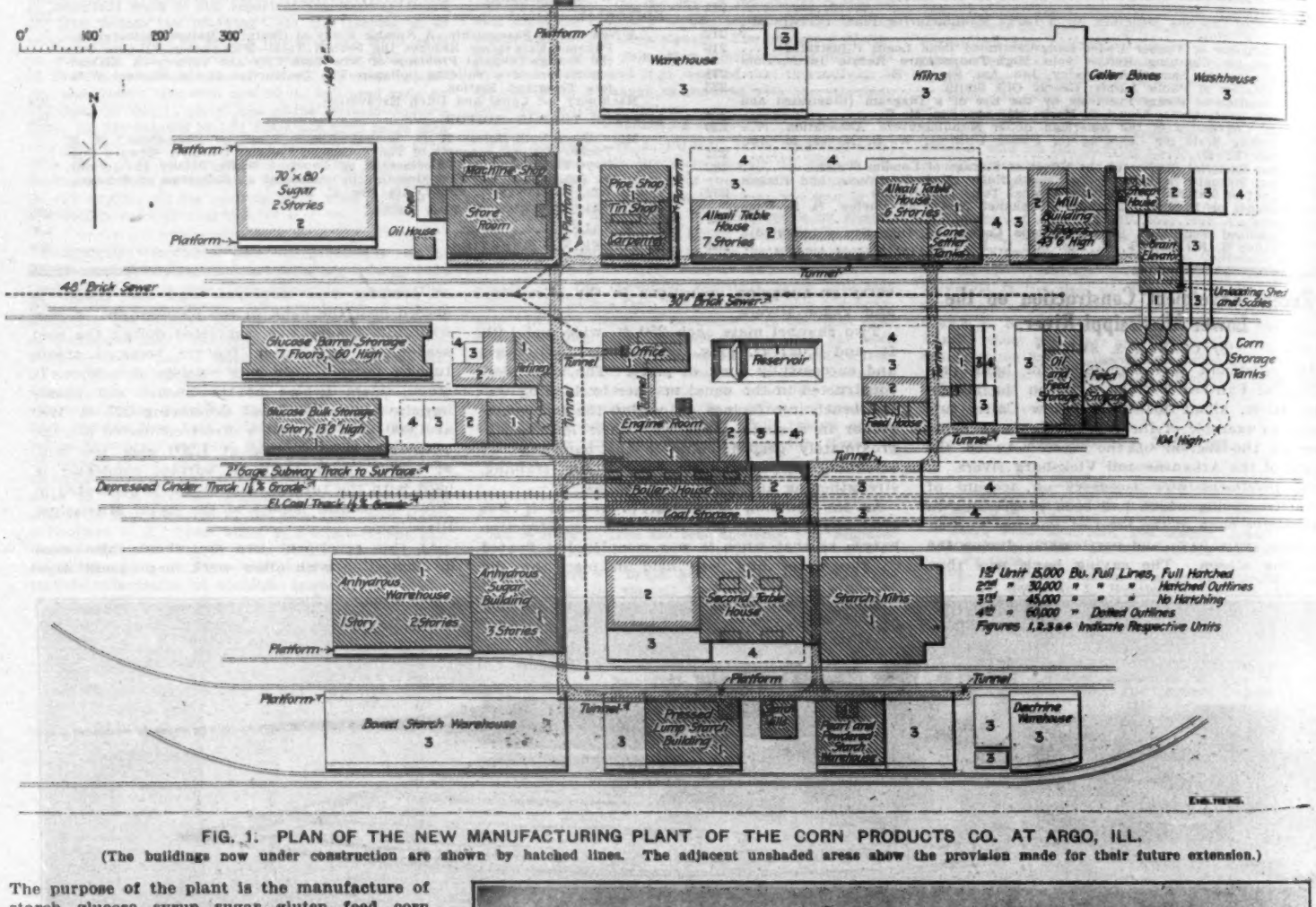

FIG. 1. PLAN OF THE NEW MANUFACTURING PLANT OF THE CORN PRODUCTS CO. AT ARGO, ILL.
(The buildings now under construction are shown by hatched lines. The adjacent unshaded areas show the provision made for their future extension.)

The purpose of the plant is the manufacture of starch, glucose, syrup, sugar, gluten, feed, corn oil, etc., from corn. Thus a great variety of conditions must be met. On a tract of 124 acres of land, one side bordering on the Chicago Drainage Canal, about 40 structures will eventually be built. It is planned to build about 30 at this time, and the remainder as demand requires. Nearly all the buildings are designed for future extensions, either in their ground area or by additional stories (or both), as may be found necessary. About 25 of these buildings have been started and several are practically completed. A plan of the main group of buildings is shown in Fig. 1. The canal lies to the west of this group.

A subway about 4,200 ft. long, for an industrial railway of 2 ft. gage and the endless variety of pipes, connects with freight elevators at all buildings. A dock warehouse, dock and slip will accommodate shipments on the drainage canal, and railway connections with near-by main lines will provide for rail shipments.

Concrete and reinforced concrete as the principal structural material was adopted after a careful study of actual costs of other buildings, and bids submitted by contractors. This indicated a substantial saving in first cost over that for steel frame buildings, and a great reduction in after costs. Of the 40 buildings, 27 are to be of reinforced concrete. The others will have steel frames encased in concrete, with concrete curtain walls and floors. The two table houses, however, have wooden floors adjustable to an exact slope by means of wedges. Some of

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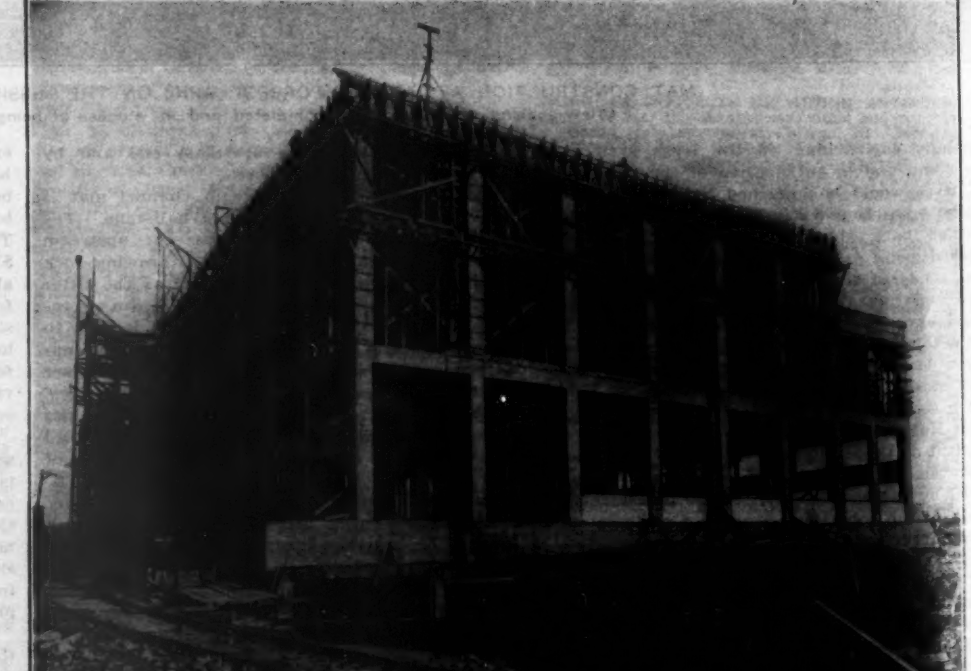


FIG. 2. ONE OF THE REINFORCED-CONCRETE BUILDINGS.
(Under the corner is seen the top of the subway which extends through the plant.)

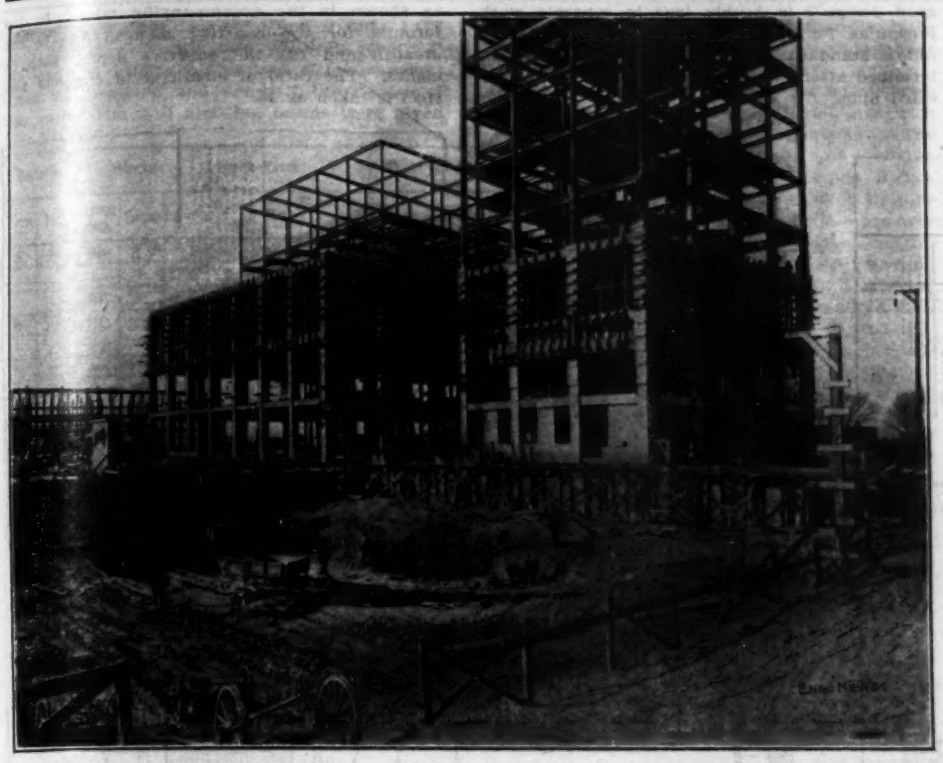


FIG. 3. STEEL FRAME BUILDING, WITH CONCRETE CASING, CURTAIN WALLS AND FLOORS.

down with emery brick and brushed over with a thin grout. Fig. 2 shows the "pressed lump starch" building, of concrete construction, with forms in place in the upper portion. At the corner of the building is seen the top of the subway for pipes and industrial railway. Fig. 3 shows one of the steel frame buildings, with the concrete covering in place in the lower stories and the forms in place for some of the upper stories.

In elevation the buildings have a large glass area. The exterior columns are generally 24 ins. face, and the lintel beams 24 ins. deep below the floor line. Below the windows is a 4-in. concrete curtain wall varying in height from 3 to 6 ft. in different buildings. The columns and lintels have a projection 4 × 1½ ins., as shown, to provide for window frames. Short beveled wood strips were embedded in the concrete at intervals, to which the frames can be nailed. Long strips were sometimes put in by the workmen, with the result of a cracked column due to the swelling of the wood. A simple parapet wall with straight lines runs around each building. Where future stories are contemplated, this wall was made of wood studding, expanded metal and plaster. Where buildings are to be extended in plan, the general external appearance is kept the same by making temporary parts of expanded metal and plaster. All windows (except in elevator shafts and stair walls) are of plain glass with wood sash.

A uniform grade of 16 ft. above water level in the drainage canal was adopted as grade or base of rail, thus allowing gravity drainage but requiring from 2 ft. to 6 ft. of filling over most of the building area. Excavation for foundations, railway yard, and street crossings below grade supplied material for this filling.

The warehouses are served by tracks, with shipping platforms on one or both sides. The platforms and first floor are built 4 ft. 6 ins. above base of rail, and over the platform is a concrete canopy, as shown in Fig. 4. The canopy projects 2 ft. beyond the edge of the platform, and slopes back towards the building. This allows large barrel cars to pass under the edge of canopy, affording protection from storm and drip, and at the same time allowing space for windows in the building above the canopy without making the first story excessively high. Some of the buildings being very wide this provision for light was necessary. A typical cross section of the side of one of the concrete buildings, showing the platform, canopy, subway, etc., is given in Fig. 4.

Footings and foundations were in all cases of concrete. These were in some cases reinforced; but generally of plain concrete, stepped up. The foundation walls which also formed one side of the tunnel, as it passed under the buildings, were about 17 ft. high. They were originally laid out as reinforced concrete, but were changed to plain concrete after work began. All external walls were reinforced for contraction. When the speed, care and regularity of handling large work are considered (the concrete being conveyed in ½-yd. Koppel cars and costing less than $2.80 per cu. yd. in place, exclusive of forms and plant), any apparent saving in thin reinforced walls or small footings soon disappears.

All footings 10 ft. square (or less) in bearing area, are of the non-reinforced type. However, under the elevator buildings and grain bins it was necessary to adopt a different type. The ground at these points was a bed of fine white sand, practically a quicksand; but very compact when free from water. The load adopted for all such material if confined was 6,000 lbs. per sq. ft. It was necessary, therefore, to cover the entire area occupied by the building, to get sufficient bearing area. The distance to rock was about 50 ft. Caissons or piers 5 ft. diameter reaching rock were considered, and estimates made in comparison with a spread reinforced-concrete footing. It appeared that the spread footing over the entire area and projecting 7 ft. all around (or 14 ft. larger each way in plan than the building) would be cheaper and much more quickly built, so it was adopted.

Under one building a flat slab resembling an inverted "mushroom" type was used. Under the other elevator building an inverted two-way reinforced floor-slab method was used, with the beams projecting above the slab (Fig. 5). The beams are a little wider than the column shoes bearing upon them. The largest beam, being between two columns with a little over 1,000,000 lbs. on each column, is 50 ins. deep by 54 ins. wide with 17 round rods 1¼ ins. diameter and round shear bars ⅝-in. diameter in each end of the beam. The columns are 18 ft. c. to c. at this place.

Column loads and spacing were very unequal, some having as low as 350,000 lbs. It was, therefore, somewhat uncertain as to how the loads would equalize over the bearing area. The beams were figured, however, for the maximum condition. For illustration: the load on beam between Cols. 6 and 7 would first be taken at 25% of the sum of loads on these columns. Then (second) 25% of the sum of the four column loads contiguous to a bay divided by the bay area was taken as the unit load for that bay, and the beam load obtained by taking such a portion of the bay load as would be transmitted to the beam by the slab (25% of the bay load if column spacing is uniform). Then design the beam for the larger load. Therefore, if the sand has a slight tendency to flow and equalize with the next row of columns, the beams are able to care for the increase. Also, the load per sq. ft.

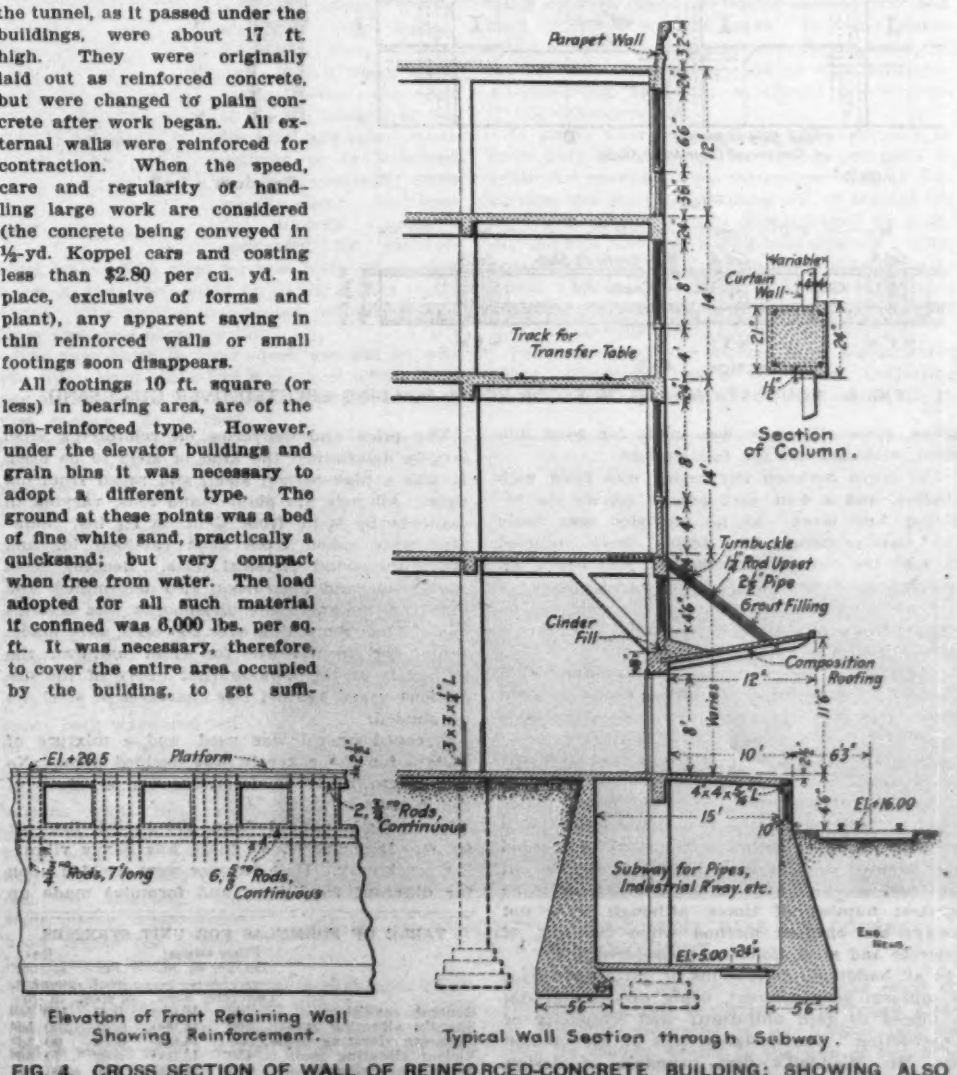
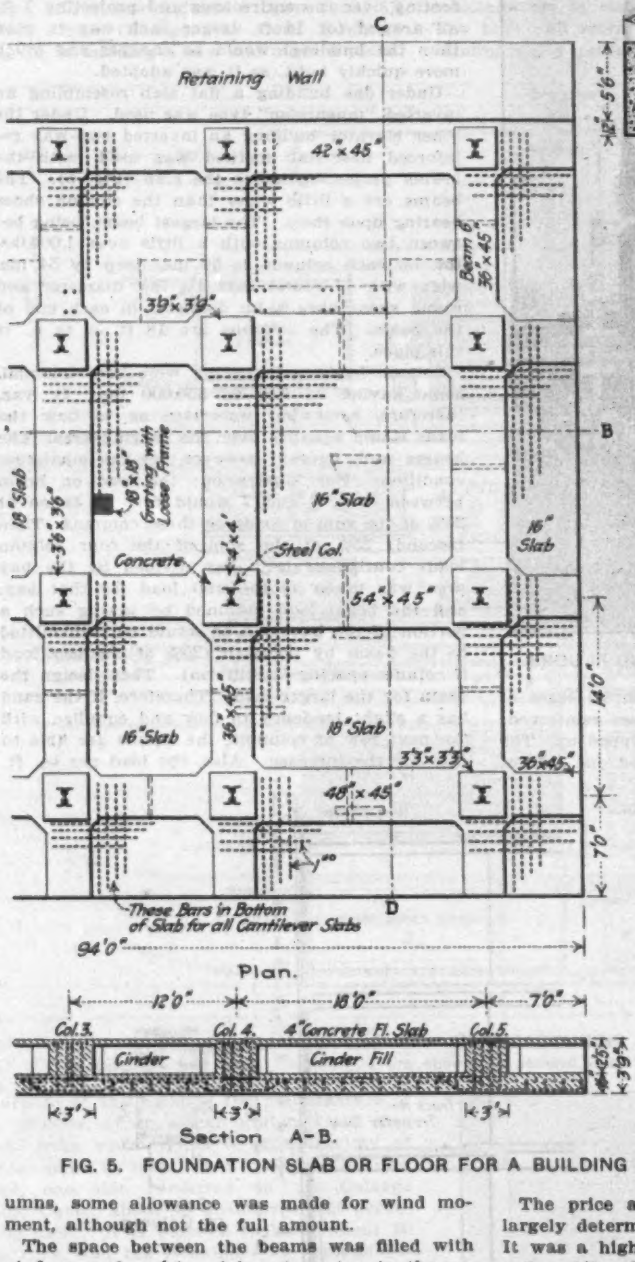
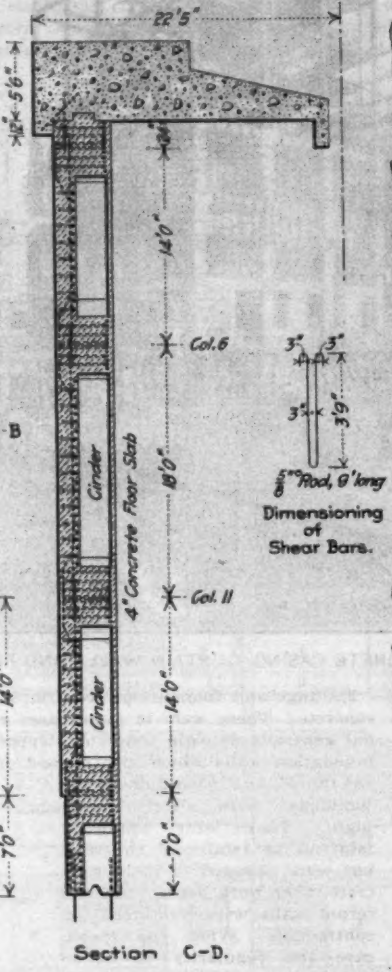
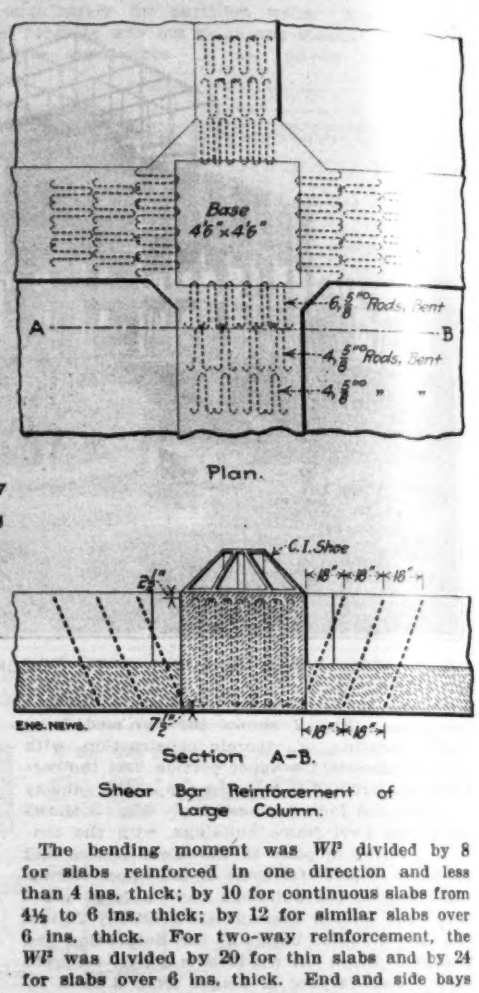


FIG. 4. CROSS SECTION OF WALL OF REINFORCED-CONCRETE BUILDING; SHOWING ALSO THE SUBWAY AND THE CONCRETE CANOPY OVER THE FREIGHT PLATFORM.

for a uniform distribution of the entire building load over the entire area was found, and no beam or slab was figured for less than would be required by this unit load. In figuring the cantilever beams projecting beyond outside columns, some allowance was made for wind moment, although not the full amount.







Shear Bar Reinforcement of Large Column.

The price and deliveries on reinforcing steel largely determined the kind of steel to be used. It was a high-carbon steel, and rolled from old rails. All rods are plain round rods, varying in diameter by ⅛-in. from ⅜-in. to 1¼ ins. Samples were taken from each car-load lot and given the usual physical tests. Bending tests were made and the carbon also determined, and in a few instances the phosphorus was determined. Thus something over 200 tests were made. While the results are far from uniform, the author is of the opinion that many of the objections urged against this character of steel are unfounded.

Screened gravel was used, and a mixture of 1:2½:5 for the concrete was decided upon. No tests were made to determine the strength of the mixture.

Floor loads ranged from 100 to 700 lbs. per sq. ft. In many places there was heavy vibrating machinery. Unit stresses were decided upon for different conditions, and formulas made up as shown in the accompanying table. [illegible] the formula for the resisting moment (b [illegible] the breadth and (d) the effective depth, [illegible] in inches. The ratio of elasticity of conc[illegible] and steel is taken as 15.

TABLE OF FORMULAS FOR UNIT STRESSES.

	Fiber stress; lbs. per sq. in.		Per cent. of steel.	Resisting moment. in.-lbs.
	Concrete.	Steel.		
General conditions.....	700	16,000	0.85	120 bd^2
Slightly vibrating loads..	500	15,000	0.75	100 bd^2
Moderate vibrating loads.	350	14,000	0.70	90 bd^2
Violent vibrating loads...	450	13,000	0.62	70 bd^2
Tanks containing liquid..	650	13,000	1.10	130 bd^2
Concrete not reinforced...	....	.....	....	14 bd^2

The bending moment was Wl^2 divided by 8 for slabs reinforced in one direction and less than 4 ins. thick; by 10 for continuous slabs from 4½ to 6 ins. thick; by 12 for similar slabs over 6 ins. thick. For two-way reinforcement, the Wl^2 was divided by 20 for thin slabs and by 24 for slabs over 6 ins. thick. End and side bays were made the same thickness as the interior bays. Usually these bays were a few inches less in dimension than the interior bays, thereby making up for the lack of continuity. In some instances slab rods were bent up into the top of the slab over the beam; but more often short pieces were laid in top of slab over the beam, to care for the negative moment. Main slab rods were spaced about 2 ins. wider apart next to the beams for about five spaces to take advantage of the varying bending moment. A larger number of

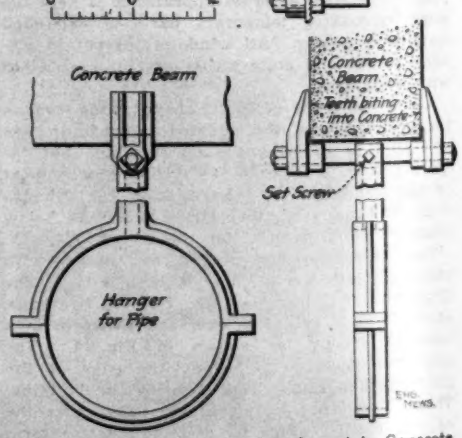


Fig. 6. Clamp Hanger for Attachment to Concrete Beams.

different spacings (such as theory indicates) leads only to neglect of the plans by the field men.

Beams were figured in most cases as a rectangular section (not T section). When con-

FIG. 5. FOUNDATION SLAB OR FLOOR FOR A BUILDING ERECTED OVER QUICKSAND.

good design") is doubly true in concrete work. Formulas for the design of all concrete parts follow standard practice, they being finally determined after the materials to be used were decided upon.

The space between the beams was filled with cinders, and a 4-in. slab put on top to the required floor level. As no provision was made for waterproofing, tile drains were inserted through the center of the beams, just above the foundation slab. This allows for drainage of any water coming through the concrete, to one central space not filled with cinders. In this a lantern hole was provided through the floor slab, through which the water could be pumped with a small portable pump. Another space between beams was provided with a grating in the floor to care for floor drainage.

For grain bins, a flat slab was used over the entire area, reinforced against upward pressure.

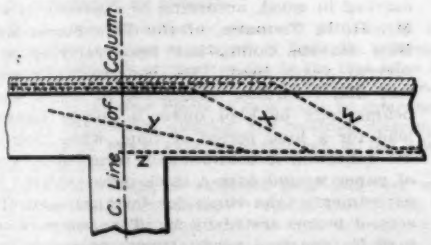
The general plan for reinforced floors in all concrete buildings is the two-way method, with beams running in both directions. This method was adopted so that form lumber would be cut the least amount, and allow its being used the greatest number of times, although it is not always the cheaper method when the cost of concrete and steel alone are considered.

In all buildings, dimensions of parts were kept as uniform as consistent, using excess material in places to gain uniformity and simplicity of construction. The designer was of the opinion that Mr. Waddell's first principle of design ("simplicity is one of the highest attributes of

tinuous over four supports or more, they were figured as continuous. Usually the full live-load and dead-load was used, although sometimes the live-load and one-half the dead-load was used. The wall abutting beams were given

Beams		Rods			Left End		Bends						Right End	
Type	No.	Total No.	Size	Length	Position	No.	a	b	c	d	e	f	Position	No.
A	8	16	⅞" ⌀	18'0"	w	2	16"	34"	17"	17"	34"	62"	—	—
		"	"	17'0"	y	2	0"	40"	12"	17"	34"	50"	×	2
		"	"	15'6"	z	2	—	—	—	—	—	—	—	—
B	10	10	"	20'0"	w	1	60"	34"	17"	17"	34"	60"	—	—
		20	"	17'6"	x	2	36"	34"	17"	17"	34"	36"	—	—
		"	"	15'6"	z	2	—	—	—	—	—	—	—	—
C	2	2	"	13'0"	w	1	16"	34"	17"	17"	34"	44"	—	—
		4	"	11'6"	y	2	0"	40"	12"	17"	34"	44"	×	2
		"	"	10'6"	z	2	—	—	—	—	—	—	—	—
D	9	18	"	20'6"	w	2	56"	34"	17"	17"	34"	56"	—	—
		"	"	18'0"	x	2	36"	34"	17"	17"	34"	36"	—	—
		"	"	16'6"	z	2	—	—	—	—	—	—	—	—
E	20	40	"	18'6"	w	2	16"	34"	17"	17"	34"	60"	—	—
		"	"	"	"	2	16"	34"	17"	24"	40"	40"	×	2
		20	"	16'6"	y	2	0"	48"	10"	10"	48"	0"	—	—
		60	"	15'6"	z	3	—	—	—	—	—	—	—	—
F	50	100	¾" ⌀	18'6"	w	2	60"	34"	17"	17"	34"	60"	—	—
		"	"	"	x	2	40"	34"	17"	17"	34"	40"	—	—
		"	"	17'0"	y	2	0"	54"	10"	10"	54"	0"	—	—
		"	"	15'6"	z	2	—	—	—	—	—	—	—	—
G	50	"	"	20'0"	w	2	12"	25"	13"	13"	25"	51"	—	—
		"	"	19'0"	y	2	0"	30"	10"	13"	25"	51"	×	2

Reinforcing Rod Schedule.



Key to "Position" of Rods.

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FIG. 7. TYPICAL BEAM AND REINFORCEMENT SHEET.

the same dimensions as the interior beams in all cases, using more steel where the interior beams were figured continuous, thus making a slight T section. When T-sections were used, the breadth of head was rarely made more than twice the breadth of flange, as the cost of steel increases beyond the saving effected in the concrete, making the beam more expensive, besides not being as safe. All the discussion in regard to the mechanics of a T section are of little practical value, as the economic section is far within the limits allowed for breadth of head by mathematical consideration only. The saving in total height of building effected by a few inches reduction in the depth of beams is of slight value, and may be neglected for low buildings. Shear was figured at 70 lbs. per sq. in. on section between center of tensile and compressive stresses. With continuous beams under vibrating loads, there is some question in the author's mind as to how much of the beam section adjoining the column is actually available for shear.

Columns were square (corners beveled), with vertical steel rods and ¼-in. tie wires about 12 in. centers. They were designed for an allowable load of 470 lbs. per sq. in. on concrete and 7,000 lbs. per sq. in. on steel, ¾-in. of concrete being allowed all around for fireproofing. The columns were proportioned for the dead-load and full live-load in the two top stories, then the live-load reduced by 5% for each floor above the column considered. The dimensions were kept as constant as possible for all buildings by varying the amount of vertical steel. At the same time this steel was kept at a low percentage, as there was not the same necessity for keeping column dimensions small as there is in a crowded city district. Not less than four ⅝-in. round rods were used in any column, and no column was made less than 10 ins. square. Spirally reinforced columns were not used for loads under 400,000 lbs.

Brackets on the columns below the beams were used only at certain points or in buildings with heavy machinery. The connections of column rods were made 9 ins. above floor level, by pipe sleeves, for buildings over two stories in height. The rods were generally so grouped in the lower columns as to allow their continuation in the column above without bending. The pipe sleeves were finally abandoned and a loose spiral hooping, a little smaller in diameter than the column, provided instead, for the lower 12 ins. of the column. In starting all columns from footings, or any other point, stub rods were provided. Thus no long loose rods projected above the concrete, with all their attendant difficulties.

Warehouse interior columns had a 3 × 3-in. guard angle on each corner for a height of 4 ft. Door jambs were made of channels, with cast-iron saddle in some places and cement in others. All outside platform edges were protected with angles. All stairs were of concrete, with a small angle nosing having the edge of one leg instead of the flat side upwards. Steel sections to be attached to the concrete, such as the above, had bent flat anchors rigidly connected by countersunk bolts. The steel sections were given open holes, so that they could be rigidly bolted to the forms. This method saved much annoyance with loose steel and anchor bolts.

The floor finish in most cases was put on with the slab. Roof slabs had a pitch of about ⅝-in. per ft. and were covered with five-ply composition roofing. In a few instances the roofs were made flat, and the slope provided by cinder filling.

It was necessary to provide means for supporting the innumerable lines of pipes and shafting in some buildings. In some floors, tapering wood plugs extending through the slab were placed about 3 ft. apart both ways and left in place. These were driven out when necessary, bolts inserted, and wooden pads bolted up. In other places, bolts were left projecting, to which wood pads can be attached. In some places, where overhead tracks for a trolley system were to be supported, special castings were provided, which permitted adjustment in two directions. A special clamp hanger was also devised by the writer, and is shown in Fig. 6. To make the teeth bite into the concrete, the lugs are hammered against the beam while a heavy strain is applied on the bolt with a wrench. This attachment is not suitable for (and not intended for) heavy shafting.

There are concrete bins for dry material and tanks for wet material. These are square, circular, hexagonal and polygonal in shape. They are supported above, set upon, projecting through and supported from the floor. There are also concrete screw conveyor troughs, drainage troughs, shaker beads and "hell holes" above, in and below the floors.

A large underground storage tank below the first floor of a building required special attention to avoid leakage, as the temperature of contents varied by over 100° F. The area was about 160 × 70 ft., with a depth of 15 ft., and was divided by cross walls into about 20 tanks 8 ft. wide. The separating walls also supported the floors above, and were designed as vertical slabs. A double wall, forming an expansion joint across the building, was provided at intervals of six or seven tanks.

Expansion joints were not provided for buildings, except for a one-story building nearly 400 ft. long. This was given a vertical division plane at the center of the building and through the column centers, thus dividing the building into two parts. Steel plates were placed vertically in the center of the wall columns, lapping past each other to prevent leakage, and a steel sliding plate placed in the floor over the expansion joint. The roof slab overlapped, thus allowing motion, but not leakage.

The subway connecting with the elevators at all buildings is generally 15 ft. wide and usually passes beneath the platform on one side of the building. Thus the subway wall on one side supports the outer edge of the platform (Fig. 4). A clearance of 9 ft. 6 ins. was adopted for headroom in the subway where it runs between buildings, and 18 ins. was taken as the minimum distance between clearance line of subway roof and base of rail or surface grade. In many places this distance was entirely too small to carry the tracks over the subway and provide adequate waterproofing, especially at curved intersections of the subway walls.

At places where the subway will eventually be built over by building extensions, provision is made for making these extensions without disturbing the piping or putting out of service the industrial track. This is accomplished by making the roof slab and beams in separately molded parts and providing temporary sections or bulkheads in side walls at column centers, so that the short sections of roof and side can be removed and new footings and columns put in place.

For supporting the piping, 5-in. I-beams are placed across the roof of the tunnel, projecting 2 ins. below the slab and spaced about 10 ft.

FIG. 8. MACHINE FOR BENDING STEEL BARS FOR CONCRETE REINFORCEMENT.

apart. Where surface railway tracks cross the subway, each rail is carried by a trough girder or H-girder composed of an I-beam laid flat with its flanges riveted to the web of two other I-beams.

Grain and feed elevator tanks 90 ft. and 93

ft. high, 30 ft. diameter, were designed according to standard practice. They were provided with two (some with five) steel hoppers in the bottom, leading to belt conveyors in a tunnel 8 ft. wide and 8 ft. high. They were provided also with a manhole near the bottom, instead of ladder. The walls were 8 ins. thick, reinforced with flat bars spaced as required.

An elevated standard gage coal track leads to the first floor of the boiler house on a grade of 1½%. A depressed cinder track a few feet from and parallel with the coal track leads to the subway level and under the concrete cinder hoppers below the stokers. A concrete trestle was proposed for the elevated track. Instead of this, however, the retaining wall for one side of the depressed track was extended sufficiently high to provide for the elevated track, and another wall was built on the opposite side. The space between the walls was filled. These walls were made light and tied together at intervals of about 12 ft. 8 ins. with cross rods encased in 8-in. concrete walls, thus taking up the thrust of the fill and train. A double cross wall was provided at intervals of about 51 ft., with an expansion joint. The retaining walls had a small amount of longitudinal steel between the expansion joints.

The smokestacks are supported at the roof line of the boiler house by the steel framework of the roof, thus effecting a saving in space in the building. They are 7 ft. interior diameter and 150 ft. high above the roof. Each stack accommodates two 500-HP. boilers. Figures and designs were received for both concrete and brick, and brick was finally adopted.

A dock warehouse with dock and ferry slip was laid out on the drainage canal. Several designs were submitted for the dock, but a solid concrete wall was adopted.

With so much construction, economy in drawings and in handling materials was of importance. General drawings were made to ¼-in. scale, and details in ¾-in. scale. Care was exercised with the steel rod details to keep the number of different lengths as small as possible, the lengths being always made in even feet and half feet, and a schedule made on each sheet of details. Fig. 7 shows a typical beam and reinforcement sheet. Even with this care the steel became spread over a considerable area, with consequent handling and storage out of doors. The rods were bent by a Hanson machine, operated by hand. This is shown in Fig. 8.

Before the plans were completed, work was commenced by a construction company organized within the Corn Products Co. specially for this work. The first thing was to enclose the property by a high board fence. Then standard gage construction tracks were laid, approximately in their final positions. A commissary department was established with finally about 20 temporary buildings to accommodate about 1,500 men. These quarters included dining-rooms and bunk houses for three grades of men, with bath rooms, recreation rooms, pool rooms, etc. Temporary saw mills, power-house, shops and storage buildings were erected.

The plant used in the excavations of building foundations included wheel scrapers, locomotive cranes handling clam-shell buckets, Koppel cars with cable haulage, and a traction steam shovel.

The concrete mixing plant consisted of four independent plants mounted on flat cars. Three of the plants had two material hoppers, one over the other, and both over the mixer. The top hopper was divided into two compartments for stone and sand. From this the proper amount of each material was drawn into the lower hopper, then the cement was added, and the charge dumped into the mixer as required. The stone and sand were supplied to two of the plants by means of belt conveyors carried on cantilever arms which were suspended from a breast derrick placed on top of the framework of the hoppers, the entire plant being mounted on a platform car. One of the mixing plants with belt conveyors is shown in Fig. 9. One conveyor arm extended from each end of the mixer car, reaching to about the center of the sand and gravel cars. The receiving end of the conveyor could be raised or lowered by means of a hand winch, placed near the mixer engine. The men shoveled the material into a small receiving hopper over the belt at the end of the arms.

One of these plants required (when running at full capacity) eight men shoveling in the stone car, three men in the sand car, five men on the mixer, and two to three men carrying cement from the car to the cement hoist on the mixer plant. The force for taking away the concrete varied with conditions, but averaged about ten men. With this force all working well (but not rushing), 16 to 18 yds. per hour could be turned out continuously. Allowance, of course, should be made for time in replacing empty with full material cars. One of the plants was supplied with stone and sand by a locomotive crane (with clam-shell bucket) running on a second track. The fourth plant was supplied by men with wheelbarrows running on a platform supported at the side and top of the material cars.

The concrete was dumped from the mixers into Koppel cars and conveyed to place or dumped into the bucket of the hoist and raised to an elevated hopper, from which it was drawn and wheeled in wheelbarrows to place. In one or two instances, tracks were mounted on top of the forms and Koppel cars used instead of wheelbarrows to distribute the concrete.

At first, the panels under the windows were cast separately and placed where possible with the locomotive crane. This method was soon abandoned as too expensive, and the panels were cast in place.

Costs were kept of all classes of work, and a daily report of the previous day's work for the entire force was sent out to each individual superintendent. The writer had understood that the superintendent on a job had a large influence on the cost, yet never before fully appreciated the extent of this influence, there being more than 150% variation with identically the same physical conditions under different superintendents or foremen.

Mr. G. E. Chamberlain was Manager of both the constructing and designing force. Mr. H. J. Bishop was General Superintendent of the construction work. Mr. F. Grim was structural engineer, and the writer was concrete engineer.

FIG. 9. CONCRETE MIXING PLANT WITH BELT CONVEYORS FOR SAND AND GRAVEL.

The Behavior of Timber Under Long-Continued Dead Loads.

Fatigue and plasticity effects seem to be very marked in wood, according to experiments which Mr. H. D. Tiemann, of the Yale Forest School, New Haven, Conn., has been carrying on for several years past. He constructed a special test and recording apparatus, in which wooden beams may be kept under a steady transverse load for a long period of time, while their middle deflection is continuously recorded on a strip of paper wound over a clock-moved drum. Such experiments take time; for instance some of the sets of beams tested by Mr. Tiemann were under load for nearly a year. It was necessary, therefore, to plan the work such as to give direct comparisons of the effect of different conditions instead of giving average numerical values for each condition for a certain kind of wood.

The nature of the apparatus used* may be understood from the photograph Fig. 1. The picture shows one beam out of a set of five which stand side by side on a trestle and record on the same strip of paper. The beams tested, so far all of long-leaf yellow pine, are 2 x 2 ins. square and about 40 ins. long, to give a span of 36 ins. between supports. Load is applied through a yoke resting on the middle of the beam and carrying weights below. Over the supports, upright carrier brackets are fastened to the beam by pins driven at the neutral axis of the beam, and across these is placed a stiff longitudinal strip from which the deflections of the beam are measured. A cord fastened to the loading yoke passes upward, around a small sheave pivoted to the strip above, and thence horizontally to the end of the strip, where it is wound around the small sheave of a multiplying wheel. From the large sheave of the latter another cord goes to the recording device.

The recorder comprises a vertical drum, rotated by clock at the rate of one revolution in 30 days (1-in. in 24 hrs.), and five pens bearing on the paper which passes over this drum. The pens are moved up or down by the cords from the multiplying sheaves. The five pens are offset horizontally, so as not to interfere with each other; the abscissas of the resulting diagrams will be correspondingly offset, but this causes no confusion in studying the results.

Up to the present Mr. Tiemann has completed four series of tests. Each comprised five beams under long-time load, a sixth piece for testing in an ordinary testing-machine, and a blank for determining the varying moisture-content of the

*For a fuller description of the machine see a paper by Mr. M. Cline, "Forest Service Tests," Proc. Am. Soc. Test. Mat. VIII. (1908), 535.

wood by frequent weighing. It is found that the change of moisture content from season to season has a profound influence on the result, the wood becoming weaker and more flexible when its moisture is higher (in summer), and stronger and stiffer when the moisture is lower (in winter). To make a set as nearly uniform as possible, all six (or seven) beams were cut from the same plank, from locations side by side.

FIG. 1. A YELLOW-PINE BEAM ARRANGED FOR TEST UNDER LONG-TIME LOAD.

(The beam is 2 × 2 ins., 36 ins. between supports. Weights apply a load at the middle by means of a yoke. A cord attached to this yoke is connected to the small sheave of the 1:5 multiplying wheel at the right. From the large sheave a cord goes to one pen of the autographic recorder. Five pens on the recorder cylinder give records simultaneously of five beams set side by side on the trestle seen in the view.)

The conclusions to which these tests have led were stated by Mr. Tiemann in a paper read before the American Society for Testing Materials at Atlantic City last June. They are essentially as follows:

1. The deflections or recoveries produced by the immediate addition or removal of loads are independent of any deflection or recovery due to the time effect of dead loads. In other words, if the deflections (or recoveries) due to the time effects of dead loads be subtracted from the stress-strain diagram, the resulting diagram is the same as would have been obtained in the usual machine test.

2. If a beam be subjected to a dead load which is less than its "immediate"* elastic limit at the time of removal of the load, and the load be removed before any failure occur and the beam allowed to recover for a length of time, then the ultimate strength as shown by the usual power-machine test is not reduced thereby, neither is the elastic limit. It appears that the latter may even be raised somewhat. The stiffness (immediate modulus of elasticity) also is not changed by the dead load.

3. The greener the wood the more plastic it is under dead load, apparently a smaller proportionate loading will cause a continual deflection until rupture finally occurs. Beams under dead load deflect more during variations in atmospheric humidity than at the average constant humidity, for during damp weather the deflections increase while in dry weather deflection becomes less or may cease altogether, but in so doing the previous deflection during the damp period is not regained. Thus the beam may continue to deflect by a series of successive stages until failure occurs, due to changes in the humidity of the air.

*By immediate elastic limit is signified that shown by an immediate load or "live" load, as by an ordinary machine test, in contradistinction to that indicated by a dead load or time test.

4. Dry longleaf pine beams may be safely loaded permanently to within at least 75% of their immediate elastic limit, provided no increase in dampness occurs, and deflections will ultimately cease (practically) under this load. No perceptible deflection will occur due to the time effect under loads up to within 20% of the immediate elastic limit. Loads greater than the immediate elastic limit are dangerous and will generally result in rupture if continued long enough.

5. The recovery of the time effect of a beam after removal of a dead load is gradual, and very similar in reverse order to the deflection under dead load. The recovery of the time effect due to removal of dead load continues longest in the beam which has been most heavily loaded, and is not always complete, the permanent "set" remaining apparently being greater the greater has been the time effect under dead load.

6. With beams under dead loads in general, if the continual deflections diminish during equal successive periods of time, the indication is that the load is safe and that deflection will ultimately cease under the same or drier moisture conditions; but if the continual deflections appear on the increase, the load is unsafe and rupture is pretty sure to follow.

The author specially emphasizes that these conclusions are only tentative, inasmuch as they are based on a relatively small number of tests. They appear to be supported very consistently, however, by the 20 beams so far tested.

Of the tests themselves we need say little farther, since the conclusions quoted above give their features of value. To exhibit the nature of the autographic records, one of them is reproduced in Fig. 2 herewith. The original of the cut was traced from the autographic record, shifting all curves so as to make their initial points coincide, and reducing the time scale by five (from 1 day per inch to 5 days per inch). The curve of moisture contents was also plotted on the copy, from the weighings of the extra piece of wood in the set.

This diagram illustrates clearly the slow increase of deflection under a constant load, and the slow recovery on partial release of load. It shows in striking manner also the effect of the increasing moisture in early summer after the furnace fires were out, as a result of which the specimens lost in strength and increased in flexibility, showing increased deflection and soon failing.

However, it is important to note that no permanent loss of strength or permanent injury is produced by the time-effect of the load. A special experiment bearing on this point was made in the first set, as follows:

The four beams of the set were loaded with 610, 730, 830 and 980 lbs. respectively. The latter failed in a few days. The others showed continuously increasing deflections, but after a time the curves flattened out considerably. After 132 days the loads were removed. Then they rested for over a year, and then were tested in the ordinary testing-machine manner. The fifth and sixth beams were tested in an ordinary testing-machine without having been subjected to time loads, one being tested at the beginning of the entire experiment period, the other at the end, to give values for comparison. After reducing all the results to a uniform percentage of moisture, they showed as tabulated below.

Allowing for unavoidable variations in quality between the different beams, it can safely be concluded from the figures of this table that the beams subjected to time load showed no loss of strength in the subsequent test to failure. The apparent lowering of modulus of elasticity is not significant, says the author, because the curves used for reducing values to uniform (10%) moisture are averages, and do not apply accurately to an individual sample.

We see, therefore, that in wood as in ductile metals, the curious actions due to plasticity, while partly permanent in effect, partly mere "lag," do not imply injury of the material, but leave the material just as strong as before, in spite of considerable plastic deformation.

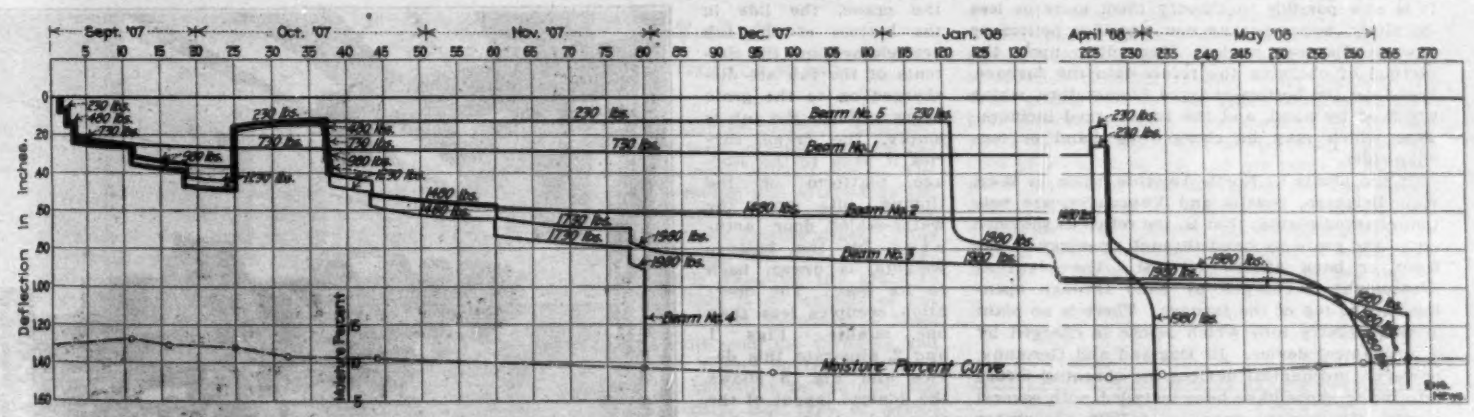


FIG. 2. A RECORD OF DEFLECTION UNDER LONG-TIME LOADING.

(Copied from the autographic record, on a time-scale reduced from 1 day per inch to 5 days per inch.)

THE FIRST BITUMINOUS COAL mined in the United States was taken from what is usually termed the Richmond Basin, a small area in the southeastern portion of Virginia, near the city of Richmond. This basin is situated on the eastern margin of the Piedmont Plateau, 13 miles above tide water, on James River. It lies in Goochland, Henrica, Powhatan, and Chesterfield counties. The coal beds are much distorted, and the coal is of rather low grade when compared with that from other districts with which it has to come into competition. The occurrence of coal was known in the Richmond Basin as early as 1700, and in 1789 shipments were made to some of the Northern States. In 1822, according to R. C. Taylor, the production amounted to 48,214 long tons (54,000 short tons). At present what little coal is produced in this field is for local consumption only.—From a report of Mr. E. W. Parker, "Mineral Resources of the United States, 1906."—U. S. Geological Survey.

Beam.		Outer-fiber stress due to time load.	Results of testing-machine tests—Fiber stress at— El. Lim. lbs./sq. in.	Ultr. Str. lbs./sq. in.	Mod. of Elast. M. lbs./sq. in.
1	No time load	.....	6,200	12,880	2,210
2	Under dead load for 132 days. Then rested 1 yr. before machine test.	6,610*	.....	.....	.....
3		5,610	7,480	12,410	1,860
4		4,930	8,580	9,900	1,680
5		4,130	7,800	13,950	1,800
6	No time load	.....	6,500	.....†	2,095

*Failed after a few days.
†Failure prematurely due to an imperfection.

Devices for Charging Refuse into High-Temperature Refuse Incinerators.

By SAMUEL A. GREELEY,* Jun. Am. Soc. C. E.

There are in the United States two quite different kinds of incinerators; one is the natural outgrowth of the early American garbage crematory, which is designed to burn garbage only and which requires the use of coal, oil, or other auxiliary fuel; the other is based largely on experience abroad, and is designed to burn mixed refuse. As distinguished from the refuse incinerator, the garbage crematory commonly burns garbage only, requires the use of an auxiliary

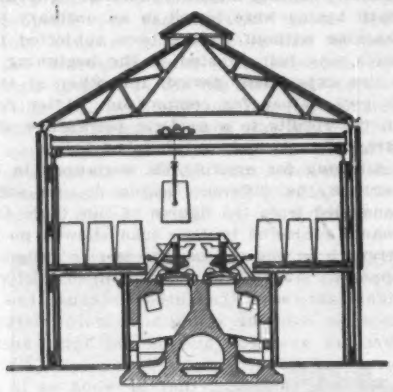


Fig. 1. Cross-Section of Refuse Destructor at Greenock, Scotland, Showing Tub-Feed System of Charging Furnaces.
(From the "Electrical Engineer.")

fuel, operates at comparatively low temperatures and is not used to generate steam. Refuse incinerators, on the other hand, burn mixed refuse, use no additional fuel, operate at temperatures averaging 1,500° F., and generate useful steam.

Already four of these high-temperature refuse incinerators have been built on this continent. In Canada, there is a plant at Westmount, near Montreal, and one at Vancouver, B. C. In the United States, there is a plant at West New Brighton, Borough of Richmond, New York City, and one at Seattle, in the State of Washington; and several others are contemplated. These high-temperature incinerators have been developed here and abroad to such an extent that it is now possible to classify them more or less definitely, somewhat as one classifies boilers or sewage disposal works. Depending upon the method of charging the refuse into the furnace, there are the bottom-charged incinerators, which are fired by hand, and the top-charged incinerators, which may be charged by hand or mechanically.

Of the plants in North America, those in West New Brighton, Seattle and Vancouver, are bottom-charged plants; that is, the refuse is shoveled on to the grate by hand through openings in the front or back of the furnace. The plant at Westmount is charged by hand through openings in the top of the furnace. There is no plant in this country into which refuse is charged by a mechanical device. In England and Germany, however, mechanical devices for charging refuse into incinerators have been installed with several plants. During the summer of 1908, the writer visited and inspected a number of these mechanically-charged plants. Inasmuch as a plant charged mechanically has not yet been built in this country, and since very little has been published here about those which have been built abroad, the writer believes that a description of some of these plants, with details of their operation, will prove interesting and valuable.

It is not intended to make any comparison between the English and American incinerators, but rather to bring out the respective features of the hand-charged and mechanically-charged incinerators of the high-temperature type. These will be described and then compared on the basis of (1) cleanliness and freedom from nuisance; (2) construction; (3) operation; and (4) efficiency as measured by the value of the output. For instance, it is claimed by some that it is more difficult to build a mechanically-charged plant than a hand-charged plant; that the hand-charged plant gives the better return in useful heat energy and at the same time entails a lower cost of repairs. Others maintain that the mechanically-charged plant operates more economically, in a cleaner fashion, and gives equally good steaming results. It will be interesting to see how these points work out when judged by actual results in practice.

*Resident Engineer on Refuse Incinerator, Board of Public Works, Milwaukee, Wis.

Greenock, Scotland.

One type of mechanical-charging device is known as the Horsfall "Tub Feed." In Great Britain it has been installed and successfully operated at Leeds, Newcastle-upon-Tyne and at Greenock, Scotland; and recently the device has been fitted to two of the furnace cells at the incinerators in Zurich, Switzerland. The incinerators at Greenock illustrate the operation of this type of mechanical device as favorably as any of the others, and it will therefore be described as typical.

The refuse burned is a mixture of garbage, ashes, rubbish and manure and is of average quality. As it comes to the plant it is dumped from the carts into a wooden tub set in a tipping-pit below the ground level. The tub is a strongly built square wooden box, large enough to hold about 1.5 tons of refuse, and is open at the top, with hinged lids at the bottom. Normally, these lids are closed tight by the rods and hooks from which the tub is suspended. The tipping pit has space for four tubs. A hopper, especially designed to prevent spilling, is arranged on tracks to move off and on over the pit. When a tub is filled with refuse, it is lifted by an electrically-operated overhead traveling crane to the platform over the clinkering floor and a little above the level of the furnace top. This platform affords sufficient space for storing eighty tubs of refuse. The opening in the top of each furnace is closed by a charging door with a water-sealed seat. Surmounting the charging door and fastened to it is a cradle of levers and balance weights. When the crane deposits a tub into this cradle, the weight of the tub causes the cradle to lower; and simultaneously the levers lift the door from its water-sealed seat and push it on guides to one side, thus allowing the lower edge of the hopper to descend a very short distance into the charging hole of the furnace. As the cradle takes the weight of the tub off the crane, the lids in the bottom of the tub are released and the contents of the tub are discharged on to the grate below. When the tub is empty, the crane carries it back to the storage platform or the tipping pit; and the water-sealed door, actuated by the balance weights, is drawn back to its seat. The operation occupies less than one minute. Figs. 1 and 2 illustrate this device and Fig. 3 shows the general layout of the Greenock plant.

FIG. 2 CHARGING FLOOR OF GREENOCK REFUSE-DESTRUCTOR PLANT, SHOWING REFUSE TUB ON OVERHEAD TRAVELING CRANE, WATER-SEALED DOORS AND OPERATING MECHANISM.

This type of charging device obviates all handling of the refuse at the plant, and the only manual work, above that required in an ordinary electric power station, is the clinkering of the furnace. Consequently, incineration plants fitted with this charging device are cleanly and free from unsightly refuse; and there are none of the nuisances or sources of infection incident to the storing of refuse in large open spaces or bins where men are working. The tubs used in the plants at Leeds, Newcastle and Greenock hold about 3 cu. yds. of refuse. When this is dumped onto the grate it forms a layer from 2 to 3 ft. thick. This thick layer requires considerable pressure on the draft in order to thoroughly supply all parts of the burning mass with air, and therefore more power is used in unproductive work than if the thickness of the fire were kept more nearly uniform. As it requires from one to two hours to reduce one charge of refuse to hard clinker, it is not possible for the fireman to "nurse" the fire, and consequently some irregularities in the temperature are unavoidable. These irregularities do not appear to be excessive and are partly compensated for by the alternate charging of the grates, thus allowing the heat from one fire at the maximum point to average with the low heat of the freshly-charged grate. Nevertheless, in the long run, charging such large quantities of refuse onto the grate suddenly, without adapting the composition of the refuse to the condition of the fire, must result in a lower average temperature. Just how this affects the useful heat energy will be brought out later. It is possible in smaller plants, where the crane is not worked up to its full capacity, to provide a larger number of smaller tubs, thus approaching the more nearly uniform rate of charging of the hand-fired plant; and if each tub were filled with an average grade of refuse, the efficiency of combustion would be still further increased.

The clinker resulting from the burning of these large charges was in every way as good as that from the hand-fired plants and showed conclusively that equally thorough combustion was obtained.

The system of levers and balance weights used to operate the water-sealed doors is by no means "fool proof" and requires careful design and operation. The flues at one plant of this type were too small properly to carry away the gases of combustion. Consequently, there was quite an outward pressure on the clinkering doors and charging doors of the furnace. The heat thus driven out of the furnace evaporated the water from the water-seats and, attacking the metal directly, cracked it so that the seats were no longer water-tight. The levers had become slightly distorted, so that the doors did not reseat themselves accurately, and on one occasion, while the writer was at the plant, it was necessary for the crane man to push the door into place. However, the other plants visited have worked satisfactorily without undue attention or repair and indicate that the fault is not wholly with the mechanically-operated charging device.

This type of device makes necessary the construction of a higher building and the installation of one or more cranes, both of which are items of increased cost. The plant cannot be operated without a crane. Experience at Greenock indicates that at least two cranes should be provided, for the only crane in service at that plant broke down for a matter of half a day and put the plant completely out of business.

Only one craneman was required at any of these plants. At Leeds, burning over fifty tons per day, the craneman had plenty of time to assist in the clinkering, so that only one other man was in attendance. One man at Greenock easily operated the crane charging six grates.

Hamburg, Germany.

In Germany, several devices for feeding refuse into incinerators mechanically have been developed. Recently Caspersohn and Uhde, at Hamburg, have been carrying on a series of experiments on the incineration of refuse which have included the design and operation of a mechanical-feeding device. The results of the experiments have not yet been published, but the experimental furnace cell fitted with a mechanical-charging device was in operation at the time of the writer's visit to the plant.

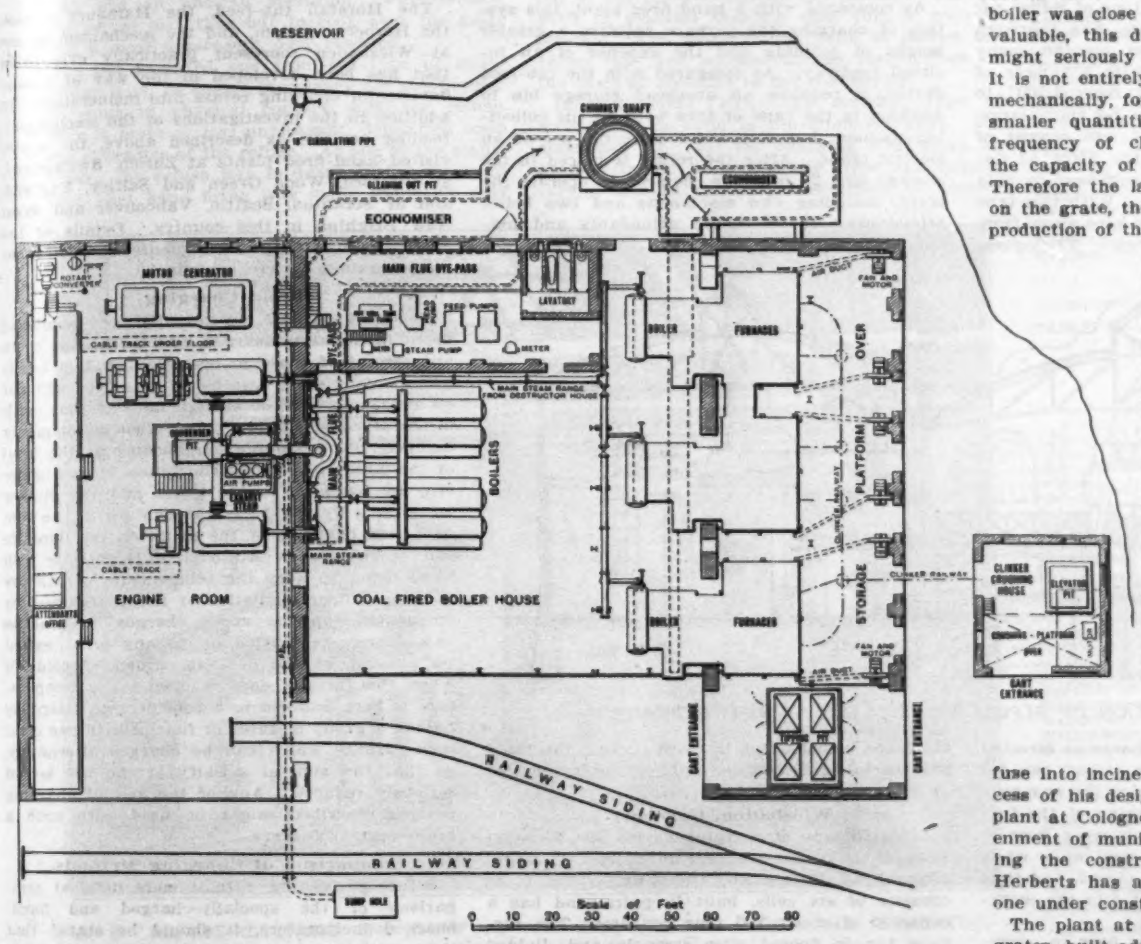


FIG. 3. GENERAL LAYOUT OF GREENOCK REFUSE DESTRUCTOR PLANT.
(From the "Electrical Engineer.")

This experimental cell consists of a grate one square meter in area placed over an ash pit and set in the vertical brick walls of the cell. Between the cell and the main flue is a large dust catcher, shaped like an inverted cone fitted with a sliding door at the bottom, and set high enough so that a car can be placed below the door to receive the dust and soot collected. This dust catcher is designed to be separate for each cell and is required because the high pressure on the draft carries large quantities of dust and soot out of the cell toward the main flue above the grate. The furnace walls are arched and there is a charging door located directly over the grate. This door is fitted with the mechanical device for delivering the refuse to the grate. It is proposed in a plant now being built in Hamburg to use a large number of cells of this design, each cell to be a separate unit, with ash pit, ash and clinkering doors, grate, charging device, dust catcher and connection to the main flue. The main flue serves as a combustion chamber connecting the different cells and carries the hot gases to the boilers. A typical section of such a furnace cell with charging device is shown by Fig. 4.

The charging device consists of a long iron drum, sliding inside of a shorter concentric drum of considerably larger diameter. These drums fit into a conical sheet steel funnel, built into the brick work of the furnace top. The two drums and the funnel form two annular triangular spaces between the vertical sides of the drums and the sloping surface of the funnel. The upper of these annular spaces opens at the floor level and the fireman rakes or shovels refuse into it from a storage platform adjacent. Raising the drum of large diameter allows the refuse to fall into the lower annular space. The outer drum is then replaced and afterwards the contents of the lower space are dropped directly into the cell by raising the smaller drum. Thus the operation of charging the furnace is performed without actually exposing the grate to the outside air, and there is no leakage of hot gases from the furnace. At Hamburg, a large open platform was built over the furnaces and the refuse was stored loosely on this platform; and from it raked or shovelled to the charging mechanism. Consequently, this type of device is not wholly mechanical, but requires a certain amount of manual handling of the refuse. The drums were raised and lowered by a differential pulley operated by the fireman on the storage platform.

This device is very simple and has few moving parts. It is arranged so that the refuse can be mixed and graded before feeding it into the fire and so that the size of the charge can be varied at will. Ordinarily, 1 cu. yd. of refuse is discharged at one time into the cell and this forms a layer 3 ft. deep on the grate. The grate is built small in area, with vertical sides, so that the refuse will fall over the grate in a layer of approximately even depth and will thus present a uniform resistance to the forced draft. This charge is burned in about thirty minutes and one man can care for the charging of two cells. One man is also required to clinker two cells. Several tests have been made with this charging device and in them the temperature varied from 1,650° to 2,000° F., the extreme minimum being 1,000° F. after clinkering. The temperature was recorded continuously in the main flue and the low points in the curve corresponded closely to the times of charging the cell.

The pressure on the draft was 6 to 7 ins. of water and large quantities of dust, amounting to about 1 cu. yd. in eight hours, were carried out of the cell to the flue. In a plant where the boiler was close to the cell and where steam was valuable, this dust settling on the boiler tubes might seriously reduce the rate of evaporation. It is not entirely possible to charge any furnace mechanically, for a long continued time, in much smaller quantities than 1 cu. yd., because the frequency of charging, necessary to maintain the capacity of the plant, becomes burdensome. Therefore the large charge, the depth of refuse on the grate, the high pressure on the draft, the production of the dust, and the periodic lowering of the temperature just after charging are inevitable.

The clinker from the experimental cell was thoroughly burned and hard. The refuse lying exposed in the charging device and upon the storage platform was unsightly and liable at any time to create a nuisance. To raise the refuse from the ground level to the storage platform required the use of a crane or of an inclined runway, both of which are elements of expense. The height of building required, while greater than for a bottom-charged incinerator, is not so great as for the plant using the tub-feed device.

Herbertz Device.

Herbertz, a contractor, with headquarters at Cologne, has developed a device for charging refuse into incinerators. To demonstrate the success of his design, he has built an experimental plant at Cologne, which operates for the enlightenment of municipal authorities who are considing the construction of a refuse incinerator. Herbertz has a plant in operation at Kiel and one under construction at Frankfort.

The plant at Cologne consists of five separate grates, built adjacent to each other. A common combustion chamber extends along the back of these grates and the hot gases from the grates pass directly through this chamber on to two water tube boilers. The grates each have an area of about ¾ sq. yd. and are made of an iron plate perforated with 24 holes for the forced draft. The cells or grates all front on one clinkering room. Above this clinkering room is a large sheet iron bin, the bottom of which has a slope of about 45° downwards to the top of the furnace. A vertical conveyor lifts the refuse into this bin. At the bottom of this slope and forming one side of the bin is a vertical sheet-iron wall; and about 3 ft. from this is a similar sheet-iron wall. Between the two walls are placed iron chutes which lead through the furnace top to the grates. An operator on a platform over the combustion chamber rakes refuse down from the bin into the chutes, and keeps

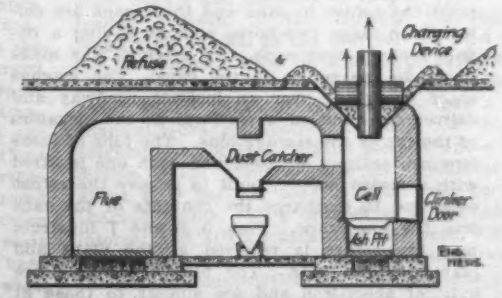


Fig. 4. Special Charging Device for Refuse Destructor, Hamburg, Germany.

them always full of refuse. The emptying of a charge into the cell is effected by means of a sliding door in the chute, which is operated by a lever from the clinkering floor. A set of signals indicates to the operator above whenever a chute becomes empty.

It was customary at the Cologne plant to charge about 1 cu. yd. of refuse on to the grate at a time. This gives a depth of refuse on the grate of about 4 ft. and requires a pressure on the draft of as much as 12 ins. of water. Each cell has a capacity of about 10 tons of refuse per day. The combustion of refuse was thorough and the recorded temperatures on the many tests, which have been made with a variety of refuse from many cities, vary from 1,200° to 2,000° F. The storage bin can be made large. At Frankfort, where the plant will consist of several units, each similar to the plant at Cologne, the bin has a capacity sufficient to hold the refuse collected in 24 hours. With this type of charging device, the refuse is kept away from the operators and well out of sight. The operator above can vary the size of charge as directed by the fireman, and, to a certain extent, can determine the grade of refuse needed for any particular charge. The actual charging of the furnace and the opening of the charging door is performed between the vertical steel walls when the doorways through these are closed, and thus the leakage of furnace gases out into the working rooms is materially reduced.

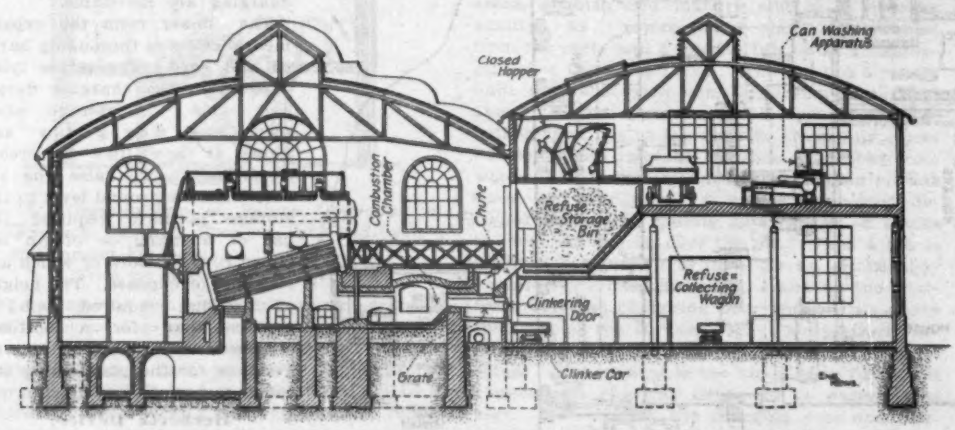


FIG. 5. CROSS-SECTION OF REFUSE DESTRUCTOR AT KIEL, GERMANY.

The Herbertz plant at Kiel has been in operation since November, 1906. It consists of three units, each unit having six cells, one combustion chamber and one water-tube boiler. In each cell is a grate having an area of about 1 sq. yd. Over each furnace is a storage bin, each having a capacity of about 100 cu. yds. The plant has a rated daily capacity of 185 tons and burns an average of 125 tons per day. The scheme of storing the refuse in closed bins out of sight and away from the workmen, was developed further at Kiel than at Cologne. The householders deposit the refuse in cans and these cans are collected on large two-horse wagons having a capacity of 44 cans each. No attempt was made to grade the refuse in the cans. The wagons enter the plant over an inclined roadway and deliver the cans on a platform at the elevation of the top of the storage bins. The tops of these bins are entirely enclosed and each one is fitted with a closed hopper, built to receive the refuse cans and to discharge the contents of the cans into the bin below. Figs. 5, 6 and 7 illustrate how the refuse is received at the plant and placed in the bins. The bins themselves are built of sheet-iron and are similar to those at Cologne. They slope at about 45 degrees to the top of the furnace over the clinkering doors and feed into chutes which guide the refuse into the cells. The chutes are filled and discharged just as they are at Cologne. The feature of the plant is that the refuse, from the time it is placed in the cans at the houses, is nowhere exposed to sight until it comes out of the furnace as clinker.

This method of unloading the refuse in the cans at the plant, although it saves the expense of operating a crane, nevertheless requires the steep haul up an inclined approach and increases the labor at the plant over that required with the tub feed. The force required during the day to deliver the refuse from the wagons to the bins comprises four workmen and an assistant emptying cans and eight women cleaning the empty cans. The women cleaning the cans should not be charged against this system, because in any system the receptacles in which the refuse is collected or stored should be cleaned.

As compared with a hand-fired plant, this system of charging the furnace requires a greater height of building and the expense of an inclined roadway. As compared with the tub-feed device, it requires an overhead storage bin in addition to the cans or tubs used on the collecting wagons; but does not require the use of an electric crane. After the refuse is placed in the storage bins 24 men are required to operate the plant, including two machinists and two boiler attendants. If the boiler attendants and machinists are not included, and if two men per shift are included for unloading cans, the labor reduces to eight men per shift on the incinerator proper.

Wiesbaden, Germany.

A fourth type of charging device has been developed by Berlit, engineer in charge of refuse disposal at Wiesbaden, Germany. This plant consists of six cells, built in pairs, and has a capacity of about 100 tons per day. The furnace top is floored over strongly and divided longitudinally into two rooms by a strong vertical wall. The cart bodies containing the refuse are hoisted by a crane and emptied on the platform on one side of the wall. On the other side of the wall are located the charging holes leading to the grate. For each two charging holes, there is one chute or tube which can be swung over either charging hole. This chute leads through the dividing wall into the refuse storage room at a height of about 7 ft. from the floor, the chute being hinged a few feet out from the wall. Directly below the chute there is a depression in the floor on the storage room in which sets a cylindrical charging can. The workmen rake the refuse, piled loosely on the floor, into this can; and then by means of a pulley and guides, raise the can until it empties the refuse it contains through the chute into the cell.

With this type of device, the refuse is piled openly in the storage room, and the workmen come in actual contact with it. This, while being a sanitary disadvantage, allows the men to deliver a fairly uniform grade of refuse to the furnace and to vary the quality of a charge to suit the fire. The cans do not contain more than 1 cu. yd. of refuse when full.

When the writer inspected the plant, the refuse slid through the chutes easily and there was no great leakage through the feed holes during charging, although the chute did not fit tightly over the door. It is possible, however, that at times these chutes would clog and cause trouble and delay.

This type of charging device does not do away with the crane, nor the open storage of refuse, and, except that it does away with the physical discomfort of hand firing, has little advantage over the hand-charged plant. Each cell was charged every forty minutes with about 1 cu. yd. of refuse. The draft was furnished to each cell by a separate motor fitted with a controlling device for changing the speed of the motor, and so the pressure on the draft to suit the condition of the fire. Mr. Berlit stated that only about 1½% of the total electrical output of the plant was used in the forced draft.

The Horsfall tub-feed, the Hamburg device, the Herbertz system, and the mechanism in use at Wiesbaden represent practically everything that has been developed in the way of special devices for charging refuse into incinerators. In addition to the investigations of the mechanical-feeding devices, as described above, the writer visited hand-fired plants at Zurich, Switzerland, at Watford, Wood Green and Saltley, England, and at Scranton, Seattle, Vancouver and West New Brighton in this country. Details of the operation of several other plants of both types were obtained by correspondence.

Hand Charging.

Since a good deal has recently been published about incinerators charged by hand and as there are several of these in operation on this continent, a detailed description of this type will not be presented. It is enough to say that with incinerators of this type, the refuse is commonly dumped into a storage bin opening at the level of the clinkering floor. The refuse is then shoveled by hand on to the grate and the clinker withdrawn by the doors through which the furnace was charged, or the doors on the opposite side of the grate. Although it is possible with hand firing to keep the temperature of the fire even by proper regulation of the charge and by frequently applying small charges, in practice this cannot be carried on to any great extent on account of the possible inrush of cold air when the furnace door is open. The temperature is kept uniform to a considerable extent by having a group of three or four cells in one common furnace which can be charged alternately, so that the general activity of the fire is not seriously reduced. Any of the special charging devices described might be used with such a multi-cellular furnace.

Comparison of Charging Methods.

Before proceeding with a more detailed comparison of the specially-charged and hand-charged incinerators, it should be stated that the completeness of such a comparison depends to a considerable extent on the quality and value of the refuse. Two plants of equally good design and economy may show very different results when compared as to efficiency of combustion, if the refuse burned at one of the plants is of greater heat value than the refuse burned at the other. Complete records of the character and composition of the refuse burned at the plants inspected are not available. At some of the installations extensive records of the composition of the refuse have been kept; but even these vary considerably from one season to another and do not always enable one to interpret the results of records of operation in a true and complete way. Such plants as the Herbertz plant at Cologne, where the refuse from about twenty different cities has been tested, give dependable data in which variations in the quality of the refuse are obscured in the general average of results. In general, it may be stated that refuse collected in Germany and in America will have a somewhat lower calorific value than English refuse. In spite of this lack of detailed information about the quality of refuse burned, it is, nevertheless, thought that the general tendencies of the types of incinerators compared will be sufficiently marked, when averaged for a large number of plants, to largely outweigh the variations in the character and fuel values of the refuse. It should also be stated that the intelligence of the labor employed affects the total efficiency of the plant. In this particular, incinerators with special charging devices have a certain advantage over hand-fired plants, in so far as they require a more skilled and intelligent class of labor to operate them.

(1) CLEANLINESS OR FREEDOM FROM NUISANCE.—Probably the most unclean type of refuse incinerator is the hand-fired top-fed plant. In plants of this type, the refuse is stored on platforms above the furnace and the men feeding the fires frequently have to walk over and through the refuse. At Hamburg and Zurich, the openings into the furnaces were closed, after charging, by jamming refuse tightly into the feeding holes. This was often done by stamping with the feet, and was an unclean operation. Furthermore, the refuse was thus left to cook over the grate and a most unpleasant odor resulted.

In the back-fed and front-fed type of incinerator it is, of course, necessary for the firemen to come in physical contact with the refuse. This is more or less unpleasant, depending upon the character of the refuse. At one of the plants visited the refuse was so dusty during the summer, that hand firing was made endurable only by sprinkling the refuse with water as it was dumped into the storage bin. In England, there was considerable discussion over the relative cleanliness of the front-fed and back-fed types, but the writer has found little to choose between them on that score.

The cleanest plants visited by the writer were the mechanically-charged plants, and particularly the tub-fed plants. In these, the refuse is not handled at all, but is conveyed in closed containers and discharged directly into the furnace. There was no refuse visible at any part of the plant. There seems to be no good reason why the fixed containers used in charging the furnace could not be either used at the houses or carried on specially-designed wagons, somewhat as at Kiel, through the city collecting the refuse from the houses, stores, schools, etc. This would avoid dumping from the collecting carts to the fixed containers at the plant, and the refuse collected in the tubs or containers could be graded as the wagons passed from house to house.

In plants charged mechanically it is necessary to keep a high pressure on the draft. In spite of this, at only one plant was there any nuisance from leakage through the charging holes.

The writer found that the higher building required in the mechanically-charged plants to accommodate the crane and charging device, considerably added to the airiness of the building. It is the opinion of the writer that the mechanically-charged plants are the cleanest and the most sanitary for the men operating the furnace.

A refuse incinerator, however, should be free from nuisance not only to those operating the plant, but also to the people living and working in the neighboring buildings. About no one of the plants visited was there any decided odor, and it was evident that in practically all well-built and well-operated incinerators, of both top-charged and bottom-charged types, refuse could be burned without offense to the community. It is necessary, with mechanical charging and high pressure on the draft, to take great precautions to keep soot and dust from being blown out of the furnace and up the chimney; but results in practice indicate that this is entirely feasible. The writer found little to choose between top- and bottom-charged incinerators on the basis of nuisance to the community.

(2) CONSTRUCTION.—The simplest type of incinerator to build is the front-fed type. Incinerators built for top charging must have an opening in the arch over the grate and require careful and substantial construction to accomplish this securely. The bottom-charged plants, and particularly those fired in front, have the charging doors in the vertical walls of the furnace and weaken the furnace structure very little. The top-fed plants further require a strong grate or a back hearth to guard against fracture from the fall of the refuse. This is true even more with the mechanical-charging devices, which frequently discharge the refuse from five or more feet above the grate level. These features add to the cost of the top-charged plants. Furthermore, the inclined approach, belt conveyor or crane used to lift the refuse above the furnace top increases the cost of the top-charged plant. Consequently, the top-charged incinerator should generally cost more than the bottom-charged type. Actual costs of construction are misleading unless one knows the local conditions controlling the building of the plant. Nevertheless, the following figures serve to throw some light on the relative construction costs of these two types of incinerators. Most of these costs are for English incinerators and cannot be used directly for American practice. It is only when used comparatively that they have value. Other features, such as style of building, greatly affect the total cost of any particular plant.

The data presented in Tables I. and II. are taken from a paper by Mr. J. T. Fetherston, read before the American Society of Civil Engineers, December, 1907; from the "Minutes of Evidence," Vol. 5, 1908, of the Royal Commission on Sewage Disposal, and from "Refuse Disposal and Power Production," by W. Francis Goodrich. The individual results differ widely and show how local conditions affect the cost of construction. There may be conditions for which a top-charged plant is the more economical. In general, however, the results point to the fact that the top-charged incinerators cost about 10% more than bottom-charged incinerators.

A mechanical-charging device fitted to a top-fed plant is an added element of cost. The incinerator at Newcastle, fitted with the Horsfall tub-feed, cost about $48,000, and has a rated capacity of 67 tons; which gives a cost per ton of about $715. At Greenock, the incinerator, with Horsfall tub-feed, cost $95,000, and has a rated capacity of 120 tons, giving a cost per ton of $790. The cost of the mechanically-charged plant at Leeds was only $375 per ton; but this plant was built adjacent to an old hand-charged incinerator where it was possible to use the flues, boilers and chimney of the old plant. Mr. George Watson, of the Horsfall Co., figures roughly on $17,000 as the cost per cell of a tub-fed incinerator. This, on a basis of 26 tons per cell per day, as at Leeds, gives a cost per ton of about $650. These figures indicate that a mechanically-charged incinerator may cost in the neighborhood of $650 to $700 per ton under conditions which would require an expenditure of about $550 per ton for the hand-fired bottom-charged plants. This difference, at 5% annual interest and 310 working days per year, reduces to about 2 cts. per ton. The figures given for the cost of construction are for the whole plant, including cells, building, chimney, runway, crane and hopper; but do not include land or any adjacent electric plants, sewage-pumping stations, etc.

(3) OPERATION.—Data showing the force required to operate the different types of plants and the cost of repairs have been obtained and are presented in Tables III. and IV., which follow. Table III., hand-charged incinerators, gives the tons of refuse which can be handled per man per hour. All of the hand-fired plants are grouped together and averaged for compari-

FIG. 6. REFUSE-RECEIVING AND DUMPING AND CAN-WASHING FLOOR AND APPARATUS, KIEL, GERMANY. (SEE FIG. 5.)

TABLE I.—AVERAGE COST OF CONSTRUCTION OF BOTTOM-CHARGED INCINERATORS.

Plant.	Rated capacity, tons of 2,000 lbs. per day.	Cost		Authority.
		Total.	Per ton.	
Aldershot	50	$5,800	$116	Goodrich
Burslem	33	18,950	574	Fetherston
East Ham	67	61,700	920	Goodrich
Eccles	53.5	22,000	412	Goodrich
Epsom	53.5	22,100	412	Goodrich
Fulham	135	82,124	610	Fetherston
Heywood	27	24,300	900	Goodrich
Hyde	80	34,000	425	Goodrich
Ilkey	22.5	7,020	312	Fetherston
Kettering	28	25,480	910	Fetherston
Kings Norton	100	73,500	735	Fetherston
Lytham	27	11,700	434	Goodrich
Manchester	33	12,700	385	Goodrich
Radcliffe	40	16,000	400	Goodrich
Rathmines	67	35,200	525	Fetherston
Salisbury	30	14,600	485	Goodrich
Seattle	60	36,000	600	Morse
Sheerness	26	17,150	635	Fetherston
Swansea	71	53,900	756	Fetherston
Taunton	60	19,500	325	Goodrich
Vancouver	48	35,000	730	Author
Watford	53.5	33,000	618	Goodrich
West New Brighton	60	about	1,000	Nutting
Weymouth	53.5	19,500	365	Goodrich
Worthing	28	21,450	765	Fetherston
Wrexham	53.5	11,324	211	Fetherston
		Average..	$508	

TABLE II.—AVERAGE COST OF CONSTRUCTION OF TOP-CHARGED INCINERATORS.

Plant.	Rated capacity, tons of 2,000 lbs. per day.	Cost		Authority.
		Total.	Per ton.	
Accrington	60	$40,000	$670	Goodrich
Belfast	134	49,000	366	Fetherston
Brentford	60	40,000	670	Goodrich
Bristol	120	60,000	500	Goodrich
Bromley	50	23,900	478	Fetherston
Burton on Trent	28	23,000	820	Fetherston
Dalmarnock, Scotland	84	66,700	794	Goodrich
Eastbourne	75	33,000	442	Goodrich
Leamington	75	30,500	405	Goodrich
Leyton	100	43,100	430	Goodrich
Llandudno, Wales	28	27,980	990	Fetherston
Ruchill, Scotland	89	100,220	1,130	Fetherston
Saltley	95	52,000	547	Fetherston
Shoreditch	112	100,500	900	Fetherston
Southwick	62	45,000	725	Goodrich
Stafford	50	19,500	390	Goodrich
St. Pancreas	160	102,900	644	Fetherston
Stockton on Teas	22.5	15,000	670	Fetherston
Walthamstow	112	49,000	438	Fetherston
Wandsworth	78	24,500	315	Fetherston
Westminster Boro	80	50,180	630	Fetherston
Winchester	20	12,400	620	Goodrich
		Average..	$615	

TABLE III.—LABOR REQUIRED IN THE OPERATION OF HAND-CHARGED INCINERATORS.

Plant.	Top-charged or bottom-charged.	No. of men per shift.	Tons of 2,000 lbs. burned.	Tons per man-hr.
Accrington	Top	5	40	.34
Saltley	Top	3	60	.83
Seattle	Bottom	4	60	.63
Vancouver	Bottom	2	50	1.00
Watford	Bottom	2	30	.63
Westmount	Top	3	30	.42
Wood Green	Bottom	2	35	.73
Zurich	Top	10	160	.67

TABLE IV.—LABOR REQUIRED IN THE OPERATION OF MECHANICALLY-CHARGED INCINERATORS.

Plant.	No. of men per shift.	Tons of 2,000 lbs. burned per day.	Tons per man-hour.
Greenock	4	110	1.14
Hamburg experimental plant	2	60	1.25
Kiel	8	125	.65
Leeds	2	53.5	1.12
Newcastle	3	60	.83
Wiesbaden	5	110	.90
Average			.98

son with the mechanically-charged plants. There is no great difference in this respect between the hand-fired bottom-charged plants and the hand-fired top-charged plants. Actual quantities of refuse burned, instead of rated capacities, are used in reducing the results to a man-hour basis.

These tables indicate that with a mechanical charging device about 1-5 of a ton more per man per hour can be handled than without it. Assuming 25 cts. an hour for labor, this difference amounts to 5 cts. per ton in favor of the mechanically-charged incinerators. For plants fitted with the Horsfall tub-feed this may be slightly greater.

The cost of repairs for incinerators varies considerably from year to year and no very definite results can be expected. The mechanically-charged plants have most of them been built within the last two years and there are very few data on cost of repairs. The plants were grouped in Tables V. and VI. according to whether they are bottom-charged or top-charged, because top charging in general is harder on the grate and hearth and because the top-charged plants are more nearly analogous to the mechanically-charged plants. The costs given in the tables are taken from the testimony of Mr. W. F. Goodrich before the Royal Commission on Sewage Disposal, from Mr. Fetherston's paper, or were furnished by Mr. H. Norman Leaske, of Manchester, England. A few of them were taken from English pamphlets on refuse incineration.

On a basis of 310 working days in a year, these average results reduce to about .50-ct. per ton for repairs for the bottom-charged plants and 2.5 cts. per ton for hand-fired top-charged plants, a balance of 2 cts. per ton in favor of the bottom-charged incinerator.

For the mechanically-charged plant at Leeds, now in its fifth year and burning 53.5 tons per day, the repairs for the year 1908 amounted to $90, or about $1.68 per ton per year, which is equivalent to 0.54 cts. per ton of refuse burned.

(4) EFFICIENCY AND VALUE OUTPUT.—Perhaps the most satisfactory way to compare different types of incinerators is on the basis of the value of the output. The usual output of a refuse incinerator comprises chiefly the clinker and the available heat energy. Both of these are largely dependent upon the quality of refuse burned, and comparative results should be reduced to the same grade of refuse. This, however, is practically impossible to do and only general tendencies can be noted by tabulating and averaging large numbers of results covering a wide range of conditions.

The writer's observations lead him to conclude that the value of the clinker is little affected by the type of incinerator in which it is burned.

FIG. 7. PLATFORM BETWEEN REFUSE-STORAGE BINS AND BOILERS, KIEL, GERMANY. (SEE FIG. 5.)

Average: tons per man per hour, .66. This average is brought down by the low figure for Accrington, which has a close, poorly-ventilated clinkering room where clinkering is hot and heavy work; and by the low figure for Westmount, where the plant is working considerably below its rated capacity. Omitting these two, the average becomes .75-ton per man per hour. Mr. Fetherston sums up his study of 27 plants, only one of which was mechanically charged, by saying that "each man employed would handle .88 short ton per hour, * * * At an easy rate of working there should be no difficulty in destroying .75-ton per hour per man." The writer's investigations bear out this conclusion.

As compared with this, Table IV. shows the quantity of refuse handled per man per hour in the plants fitted with mechanical-charging devices.

Herbertz, who is building a mechanically-charged plant at Frankfort, has stated that the guaranteed force required to operate each unit of four grates is three men per shift of eight hours. At the capacity planned for, as based on experiments made at Cologne, this averages to 1.10 tons per man-hour.

TABLE V.—APPROXIMATE COST OF REPAIRS FOR BOTTOM-CHARGED INCINERATORS.

Plant.	Tons of 2,000 lbs. burned, per day.	Cost of repairs per year. Total.	Per ton.
Aldershot	13	$0.90	$0.[illegible]
Birmingham	37	40.00	1.[illegible]
Burslem	40	7.00	.[illegible]
Gosport	33	243.00	7.[illegible]
Grays	12	25.00	2.[illegible]
Hereford	12	21.00	1.[illegible]
Levenshulme	50	8.00	.[illegible]
Lytham	13	5.00	.[illegible]
Manchester	60	122.50	2.[illegible]
Radcliffe	39	85.00	2.18
Sheerness	14	14.00	1.[illegible]
Watford	30	50.00	1.67
Weymouth	20	8.40	.42
Worthing	21	32.00	1.52
Wrexham	33	21.00	.64
Average			$1.50

TABLE VI.—APPROXIMATE COST OF REPAIRS FOR TOP-CHARGED INCINERATORS.

Plant.	Refuse burned, tons of 2,000 lbs. daily.	Cost of repairs per year. Total.	Per ton.
Belfast	90	$490.00	$5.45
Bolton	50	68.00	1.36
Cambridge	29	290.00	10.00
Fulham	118	14.80	12.50
Hackney	142	22.50	15.80
Leamington	39	73.00	1.87
Rotherham	56	315.00	5.62
Royton	16	146.00	9.15
Southampton	45	340.00	7.55
Average			$7.90

Thus at Zurich, a hand-charged top-fed plant, the clinker and ash were sold for concrete and artificial stone and brought 35 cts. per cu. yd. The clinker from the mechanically-charged plant at Newcastle was crushed and used in city streets as a surface grit to prevent horses from slipping. The clinker at Greenock was crushed, graded and sold, and was of excellent quality, hard and durable. The clinker from the hand-charged plant at Watford was used successfully for building sewage-disposal works [filter beds]. Local conditions affect the value of clinker so greatly that, relatively, the method of charging has almost no effect.

On the other hand, the method of charging has an important influence on the value of useful heat energy obtained from the refuse. Tables VII. and VIII. indicate the extent to which the useful heat energy returned is influenced by the method of charging.

Nineteen tests were made at the mechanically-

TABLE VII.—EVAPORATIVE RESULTS OBTAINED IN TESTS OF HAND-FIRED, TOP-CHARGED INCINERATORS.

Plant.	Date of erection.	Pounds of water evaporated per pound of refuse from and at 212° F.
Accrington	1900	1.39
Ashton on Lyne	1901	.78
Birmingham (Montague St.)	1879	1.56
Bradford (Humerton St.)	1898	1.25
Bury	1901	.94
Canterbury	1890	1.54
Fleetwood	1900	1.19
Fulham	1901	1.30
Hackney	1902	1.42
Llandudno	1898	.86
St. Helens	1899	1.54
Shoreditch	1897	.96
Saltley	....	1.82
West Hartlepool	1901	1.25
Wandsworth	1897	1.24
Westmount	1899	1.36
Average		1.27

TABLE VIII.—EVAPORATIVE RESULTS OBTAINED IN TESTS OF BOTTOM-CHARGED INCINERATORS.

Plants.	Date of erection.	Pounds of water evaporated per lb. of refuse from and at 212° F.
Ayer	1903	1.58
Burnley	1902	2.00
Burslem	1889	2.16
Darwen	1899	1.48
Eccles	1904	1.35
Grays	1901	1.22
Gloucester	1902	1.74
Kings Norton	....	2.63
Hereford	1897	1.67
Lancaster	1901	1.63
Mansfield	1903	1.80
Nelson	1900	1.77
Northampton	1903	1.32
Preston	1903	1.70
Rathmines	....	1.78
Rochdale	1894	1.81
Salesbury	1902	1.23
Seattle	1907	1.
Watford	1903	1.56
West New Brighton	1908	1.32
Average		1.67

TABLE IX.—APPROXIMATE ANNUAL SAVING IN COAL, DUE TO THE USE OF STEAM GENERATED AT TOP-CHARGED INCINERATORS.

Plant.	Refuse burned, tons per day.	Annual saving in coal. Total.	Per ton.
Acton	50	$1,130	7.3 cts.
Kamington	39	900	5.8 cts.
Leyton	160	1,000	2.2 cts.
Newmarket	12	1,000	29.4 cts.
Walthamstow	67	3,150	15.0 cts.
Westmount	30	3,000	33.3 cts.
		Average....	15.5 cts.

TABLE X.—APPROXIMATE ANNUAL SAVING IN COAL, DUE TO THE USE OF STEAM GENERATED AT BOTTOM-CHARGED INCINERATORS.

Plant.	Refuse burned, tons per day.	Annual saving in coal. Total.	Per ton.
Aldershot	13	$1,700	42.1 cts.
East Ham	33	4,850	47.4 cts.
Eccles	31	1,700	17.6 cts.
Epsom	13	1,800	44.6 cts.
Gosport	33	1,950	19 cts.
Hereford	12	1,950	52.5 cts.
Lytham	13	1,330	33 cts.
Taunton	22	560	8.2 cts.
Watford	30	1,600	17.2 cts.
Weymouth	20	1,820	20.3 cts.
		Average....	31.1 cts.

charged plant at Cologne and the average actual rate of evaporation was 1.01 lbs. of water per pound of refuse at 140 lbs. steam pressure. This is equivalent to about 1.25 lbs. of water per pound of refuse from and at 212° F. The Greenock plant, when tested, gave an evaporation from and at 212° F. of 1.41 lbs. of water per pound of steam. At Kiel the evaporation from and at 212° F. is about 0.95 lbs. of water per pound of refuse and at Wiesbaden about 1.08. These results indicate that hand charging will give an evaporation from and at 212° F. per pound of refuse of about 0.40 lbs. of water more than can be obtained with a mechanical-charging device.

Tables IX. and X., with but two exceptions, were compiled from the testimony of Mr. W. F. Goodrich before the Royal Commission on Sewage Disposal. They show the saving in coal at sewage-pumping stations or electricity works where refuse is used to generate part of the steam.

These two tables confirm the evidence of Tables VII. and VIII. that the value of the useful heat from refuse used to raise steam is greater for the hand-fired bottom-charged plants than for the top-charged plants.

Mr. W. F. Goodrich, in his book entitled "Refuse Disposal and Power Production," presents a table showing the number of electrical units generated per ton of refuse destroyed at twenty combined electricity and destructor works. If the top-charged and bottom-charged plants listed in these tables be averaged separately, the results would show an output of 30 KW.-hrs. per short ton for the top-charged incinerators as against 40 KW.-hrs. per short ton for the bottom-charged incinerators.

These results have been bettered considerably in more recent installations. Tests made on the top-charged plants at Bradford and Hackney and on the mechanically-charged plant at Greenock developed 60, 50, and 80 KW.-hrs. per short ton of refuse burned respectively, the average being 63.3 KW.-hrs. per ton. The bottom-charged incinerators at Stoke-upon-Trent, Woolwich, Preston, and St. Albans developed, on tests, 97, 90, 90, and 92 KW.-hrs. per ton respectively, the average being about 92 KW.-hrs.

In comparing the efficiencies of incinerators on the basis of electrical units generated, the efficiency of the machinery becomes a factor, as well as the grade of the refuse, and the results are not so reliable as the evaporative tests. Nevertheless, the evidence is strong that with bottom charging as compared to top charging, a greater output of electrical units may be expected. This difference may amount to 20 KW.-hrs. per short ton of refuse.

Most of the above results are confined to hand-fired plants. Such results as are given for mechanically-charged plants indicate that these do not differ greatly from results obtained with the hand-fired top-charged plants and that as compared with bottom-charged incinerators, the results tabulated for hand-fired top-charged plants are a good index of the efficiency of the mechanically-charged plant. If we assume steam to be worth 3 cts. per 100 lbs. and electric power to be worth 1 ct. per KW.-hr., then we have as the value per ton of bottom charging over top charging, the following results for each of the bases taken for comparison:

On basis of evaporation	24	cts. per ton.
On basis of saving in coal	15.6	cts. per ton.
On basis of electrical output	20	cts. per ton.
Average	19.9	cts. per ton.

It must, however, be remembered that, except for the results based on the annual saving in coal, the results are based chiefly on test runs and not on every-day working conditions. In view of the fact, the writer believes the value of hand firing in bottom-charged plants over top-charged plants is not generally over 13 to 15 cts. per ton. This is particularly true because, in steam plants using refuse for fuel, it is the minimum power developed that determines the true rating, and it is only in works where a considerable portion of steam is raised in coal-fired boilers that the irregularities in the fuel value of refuse can be somewhat reduced. The saving in coal should be a good index of the value of the refuse as fuel in such a works. This element of value in bottom charging over top charging applies only where steam is valuable.

These various points may be summarized as follows:

(1) Cleanliness: Mechanical charging offers the greatest opportunity for cleanliness, within and about the plant, of any type of incinerator and causes no more nuisance to the community.

(2) Construction: A mechanically-charged incinerator, other things being equal, will cost about $125 per ton of rated capacity more than a bottom-charged incinerator. This is equivalent to a difference of about 2 cts. per ton of refuse burned.

(3) Operation: By using a mechanical-charging device, about one-fifth of a ton of refuse per man-hour can be handled more than with hand firing in bottom-charged incinerators. This is equivalent to about 5 cts. per ton of refuse burned. A mechanically-charged plant may cost from 1 to 2 cts. more per ton for *repairs* than the bottom-charged plant.

(4) Value of Output: There is little difference in the value of the clinker from the different types of incinerators. The useful heat energy from the hand-fired bottom-charged plants is worth from 13 to 15 cts. per ton of refuse burned more than the useful heat energy from mechanically-charged incinerators.

Within the range of capacities of the plants investigated (say up to 100 tons daily capacity) and in communities where steam has a distinct value, the evidence presented indicates that hand-fired bottom-charged incinerators are the most economical type. In communities where steam raising is not of prime importance, or where power cannot be readily marketed, mechanical charging has many advantages. Some of these cannot be expressed in terms of money value. Thus for each community, the controlling factors must be determined and the type of incinerator best adapted to these conditions must be selected.

It is only fair to state, however, that special devices for charging high-temperature incinerators are a comparatively recent development in refuse incineration and have not yet been developed to the same extent to which hand charging has been carried. The facts that the sudden fall of a considerable charge of refuse may be received on a drying hearth at the back of the furnace and thus kept from submerging the burning mass on the fire-grate proper, and that the grade of refuse may be kept uniform even in the tub-fed type of plant by taking special care to fill each container with the proper proportions of each constituent of refuse, leads one to believe that the amount of useful heat in the refuse may be developed in mechanically-charged plants to more nearly the same extent to which it is developed by hand firing. Add to this the consideration that mechanical charging permits of greater cleanliness in operation and forces the use of skilled labor, and it becomes evident that, for some conditions, mechanical charging may be the more advantageous. Although at present hand firing in bottom-charged incinerators gives the greater economy where steam has a distinct value, the writer believes that mechanical charging holds a real and useful position in the science of high-temperature refuse incineration.

Classification of Public Lands.*

By GEORGE OTIS SMITH.†

The necessity for classifying the public lands is not a recent discovery. The earliest land legislation in this country both contemplated differences in the quality and character of the public lands and planned for descriptions based on field examination. Yet even the honest administration of the land laws has ever been subject to criticism arising from the fact that no adequate provision was made for land classification.

A period of national awakening to the worth of the public domain followed the close of the Civil War, and another epoch of realization by the nation of the true source of its wealth and prosperity has just opened, while both the legislative and executive branches of the Federal Government are awake to the fact that exact knowledge is essential to the proper utilization of our country's great resource of land. The earlier propaganda bore fruit in the creation of a scientific bureau among whose functions was the classification of the public land, but this specific duty was subordinated to the more general task of determining the natural resources of the public domain. The duty of classifying the remaining unentered public lands is now definitely accepted by the United States Geological Survey, and the opportunity earlier neglected has for several years been vigorously improved. The Survey is heartily cooperating with the General Land Office to the end that the best disposition of the land may be secured, and it should be noted that no small part of the data utilized in this work represents the fruitage of the Survey's earlier general investigations.

Utilization is the keynote of the present public land policy, and by utilization I mean not that kind of local development that is promoted by the "land skinner," but rather a development whose plan weighs national needs and calculates future demands and whose accomplishment will serve our country's development in the next century as well as in the present decade. Utilization is opposed to both non-use and waste.

A notable example of land classification in aid of proposed legislation is afforded by the Acts of March and October, 1888, wherein Congress directed that an irrigation survey should be made by the Geological Survey and that the reservoir sites and irrigable lands designated as a result should be reserved pending further legislation. The legislation of 1888 was itself the logical outcome of Major Powell's 1879 report on the arid lands and his subsequent work as Director of the Geological Survey, and the law that eventually resulted from the work thus authorized in 1888 was the Reclamation Act of 1902, through the operation of which the West is coming into its own as the garden of the nation.

Hydrographic and topographic surveys which are now in progress under instructions of the Secretary of the Interior have as their purpose the collection of information that may be presented to Congress in aid of legislation looking toward the best utilization of the water powers of the public domain. Reports on the mineral or non-mineral character of coal, oil, and phosphate lands of which the Survey has made actual field examination are now being transmitted to the General Land Office. Another line of activity is the segregation of non-irrigable lands under the terms of the "enlarged homestead act" of the present year. The existence of Survey data whereby within the few months since the passage of this law the Secretary of the Interior has been able to designate 162,000,000 acres is in itself a forceful argument for an adequate land classification.

The classification and valuation of coal land is a special phase of public land work to which the Geological Survey is giving increased attention. The geologic investigations of the last three field seasons have not only furnished a knowledge of the quantity and quality of the coal on the public domain, but have rendered possible the present policy of obtaining coal prices for coal lands. The General Land Office now depends on the Geological Survey to furnish detailed valuations for every 40-acre tract of coal land that is placed on the market. In the two and a half months following the adoption of the revised scheme of valuation the reports to the General Land Office released to agricultural entry approximately two and a half million acres in Colorado, Wyoming and Montana and placed selling prices on nearly 400,000 acres of coal land with an aggregate valuation of over $15,000,000. The price of government coal land is now determined on the basis of estimated

*Abstract of address delivered at National Irrigation Congress, Spokane, Wash., Aug. 11, 1909.

†Director, U. S. Geological Survey.

tonnage, the unit rate varying with the quality of the coal from ½ ct. to 3 cts. a ton for coal deposits within 15 miles of a railroad. These prices average less than one-tenth the usual royalty paid in the West. Yet this conservative valuation will more than double the average price of public coal lands. In exceptional cases the price based on tonnage represents a fifteen-fold increase over the old minimum price. It is conceded that this policy of basing the price on the quantity and quality of the article sold will not encourage purchase by speculators, but I maintain that the government valuation will not impede the disposition of the coal deposits for purposes of utilization. The real development of the West will be promoted, not retarded. The increased valuation of the millions of acres of public coal land must result in increased contributions to the Reclamation Fund and greater possibilities for local utilization of the agricultural lands through irrigation.

A principle that is winning increased recognition in land legislation is that of relative worth. The present coal land law expresses this principle by giving gold, silver and copper deposits priority over the coal, and the coal in turn preference over agricultural values. These distinctions necessitate land classification based on adequate field examination. Wherever the different values can be separated that separation by appropriate legislation is at once the easiest and best solution of the problem, and the first step in this direction was taken in March of this year in the passage of the Mondell Act whereby the homeseeker may secure all for which he makes entry—all that he swears he is getting—while the coal beneath his tillable land is reserved to the nation for future disposal.

The ideal land classification is that based on field examination, scientific and detailed enough to include every natural resource; the ideal land legislation is that which fully recognizes the principle of relative worth; and the ideal land administration is that which will assure the reservation or the disposition of the land for its highest use.

[The Mondell Act, approved March 3, 1909, is reprinted below.—Ed.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That any person who has in good faith located, selected, or entered under the nonmineral land laws of the United States any lands which subsequently are classified, claimed, or reported as being valuable for coal, may, if he shall so elect, and upon making satisfactory proof of compliance with the laws under which such lands are claimed, receive a patent therefor, which shall contain a reservation to the United States of all coal in said lands, and the right to prospect for, mine, and remove the same. The coal deposits in such lands shall be subject to disposal by the United States in accordance with the provisions of the coal-land laws in force at the time of such disposal, but no person shall enter upon said lands to prospect for, or mine and remove coal therefrom, without previous consent of the owner under such patent, except upon such conditions as to security for and payment of all damages to such owner caused thereby as may be determined by a court of competent jurisdiction: Provided, That the owner under such patent shall have the right to mine coal for use on the land for domestic purposes prior to the disposal by the United States of the coal deposit: Provided further, That nothing herein contained shall be held to affect or abridge the right of any locator, selector, or entryman to a hearing for the purpose of determining the character of the land located, selected, or entered by him. Such locator, selector or entryman who has heretofore made or shall hereafter make final proof showing good faith and satisfactory compliance with the law under which his land is claimed shall be entitled to a patent without reservation unless at the time of such final proof and entry it shall be shown that the land is chiefly valuable for coal.

EFFICIENCY OF INCANDESCENT ELECTRIC LAMPS.—A series of studies on the absolute efficiency of light production of the common incandescent lamps was made in 1908 at the University of Vermont under direction of Prof. W. H. Freedman, M. Am. Inst. E. E. These are reported in the "Vermont Engineer" (1909 annual). A method of finding the ratio of light radiation to total was adapted, using a thermopile and galvanometer. One face of the thermopile was carefully protected from temperature changes and the other was exposed to the lamp under study. The galvanometer was in series with the thermopile alone. A double screen of non-conducting material (for heat) was placed between the lamp and thermopile, but the screen contained openings which could be opened and closed by slides from a distance. A glass cell, carrying water, was used between the lamp and screen to cut off the non-luminous rays when desired. The first kick of the galvanometer on opening the screen was taken as proportional to the radiation received by the thermopile. The ratio of kicks under exposure to luminous and to total radiation was taken as the radiant efficiency of the lamp under study. No correction was made for the absorption or reflection of luminous rays by the glass cell. Under these conditions the following average figures were obtained, for lamps on rated voltages:

Ordinary "Edison" 16 c. p.	7.00%
Ordinary "Munder" 16 c. p.	6.14"
"Edison" "Metallized" 25 c. p.	8.05"
"Just" Tungsten, 40 c. p.	11.20"
"Edison" Tungsten, series, 7½ amp.	11.51"
"Edison" Tungsten, 80 c. p.	11.77"
"Edison" Tantalum, 22 c. p.	8.84"

The Solution of Steam Problems by the Use of a Diagram.

By LIONEL S. MARKS,* M. Am. Soc. M. E.

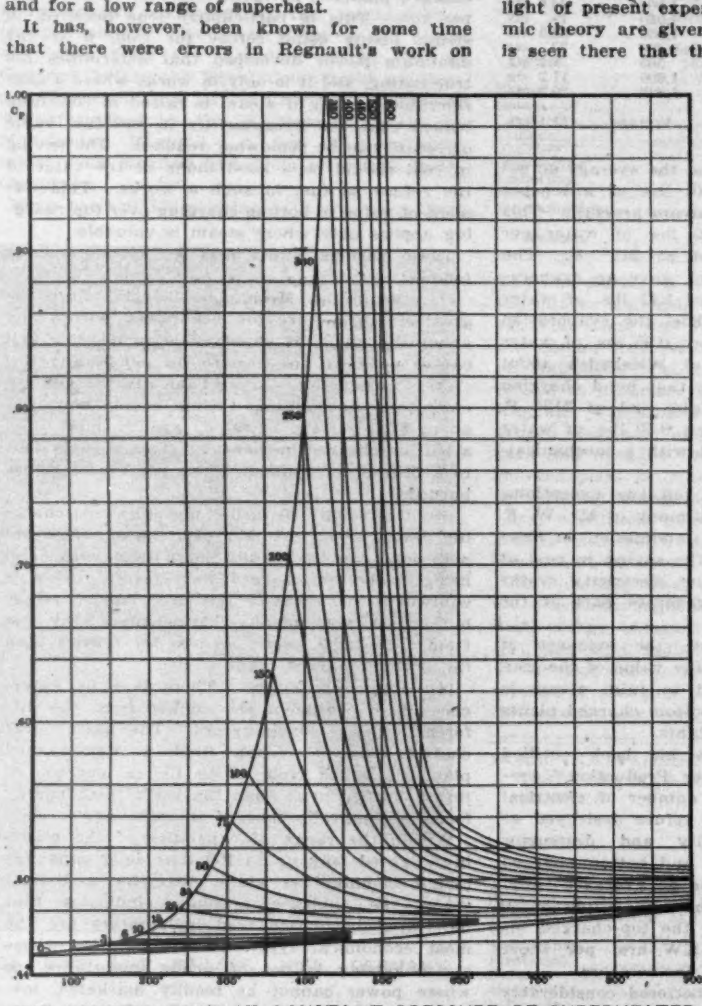
(With two-page plate.)

In making calculations which involve a knowledge of the properties of steam, engineers have used, for over sixty years, the values which Regnault deduced from his splendid investigations. They have used Regnault's equation for the total heat of dry and saturated steam:

$$H = 1091.7 + 0.305\ (t - 32);$$

an equation which makes the total heat increase proportionately to the increase in temperature. They have also assumed the specific heat of superheated steam to be constant at all temperatures and pressures and have used that value which Regnault found at atmospheric pressure and for a low range of superheat.

It has, however, been known for some time that there were errors in Regnault's work on saturated steam resulting from two causes: (1) the practical impossibility of obtaining dry and saturated steam by his method, and (2) from an accident to his apparatus, to which he himself refers. It is also apparent on examining his experimental results that his own equation (given above) does not represent the results with sufficient accuracy.



THE SPECIFIC HEAT AT CONSTANT PRESSURE OF SUPERHEATED STEAM.

(Each curve shows the specific heat at some one pressure and for a considerable range of temperature. The limiting curve to the left is the saturation line.)

Within the past month new values of the total heat of saturated steam have been published† which, it is believed, are accurate to within one-tenth of one per cent. and which may probably be regarded as final for the purposes of the engineer. These new values do not show a simple relation between total heat and temperature. For the range of temperature from 212° to 400° F., the relation is given by the equation:

$$H = 1150.3 + 0.3745\ (t\text{-}212) - 0.000550\ (t\text{-}212)^2$$

Below 212° the new values are well fixed by a number of individual determinations, but have not been represented by any simple equations.

The condition of our knowledge of the properties of superheated steam has until very recently been highly unsatisfactory. The recent investigations of Knoblauch and Jacob, of Thomas, and of Henning, however, permit a determination of the specific heat at constant pressure of superheated steam with a degree of accuracy which is satisfactory for all purposes of the engineer. The relations between this specific heat and the temperature and pressure of the steam cannot be represented by any simple formula; the values which appear to be the most accurate in the light of present experiments and of thermodynamic theory are given graphically in Fig. 1. It is seen there that the specific heat varies both with pressure and temperature, and that for those pressures at which superheated steam is commonly generated, the variation of the specific heat is very considerable.

The calculation of the total heat and entropy of superheated steam was simple under the old assumption of constant specific heat, but gave errors which, in the light of new knowledge, are seen to be inadmissible. Unfortunately, with the new data, the calculation of these quantities become extremely laborious. The old assumption had the advantage also of permitting an easy mathematical solution of the more common problems involving superheated steam. It was for example, easy to calculate the change in the condition of superheated steam during adiabatic expansion. With the newer data such calculations are only practicable by a tedious process of trial and error. There are also problems incapable of direct accurate solution, for which empirical equations had been deduced; such as Zeuner's equation for final pressure of saturated steam which has expanded adiabatically through a known ratio of expansion. Such equations can no longer be regarded as sufficiently accurate for the calculations of the engineer.

There are two possible ways of finding the properties of steam (that is, of determining the simultaneous physical coordinates of steam) and of solving many of the more common problems, without actually calculating the desired quantities. These methods are (1) by the use of properly arranged steam tables, and (2) by the use of an appropriate steam diagram. All engineers are accustomed to the use of steam tables for finding the properties of dry and saturated steam. If the properties of wet steam are required, it is a very simple matter to calculate them from the steam table. For superheated steam there has been no need of tables until the present time; but now, if the accurate data are to be used, a steam table (or its substitute, a steam diagram) is absolutely necessary. It is not practicable to construct a superheated steam table to give the properties of steam for every degree of superheat within the range of modern

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†Steam Tables and Diagrams, by L. S. Marks and H. N. Davis, published by Longmans, Green & Co., July, 1909. The accompanying two-page plate is compiled from the large steam diagrams of this book and is published here by permission of Messrs. Longmans, Green & Co. Acknowledgment is also made for permission to reproduce from the same source the figure given in the text.

practice; such a table would cover several hundred pages of an ordinary octavo book. Consequently, it is generally necessary to interpolate in superheated steam tables. If the steam properties are given for every pound pressure and for every ten degrees of superheat, the interpolation is easy. It is more accurate and probably more expeditious to obtain the properties of steam from such a table than from a steam diagram. When, however, steam problems have to be solved—especially the very common problems involving adiabatic expansion—such a table becomes markedly less convenient than an appropriate steam diagram.

It is possible to arrange a steam table in such a manner as to facilitate the solution of particular classes of problems. One well known authority on steam tables has published a table occupying about 50 large octavo pages which is intended primarily for the solution of problems involving adiabatic expansion. Such a table is inferior in convenience to a steam diagram, because it is generally necessary to scan several pages before the desired page can be found and also because of the difficulty of interpolation. The principal objection to it is, however, that it is extremely inconvenient for the most common purpose of the user of the book; namely, for finding the properties of steam.

If, for example, the total heat or specific volume of steam at 130 lbs. pressure, superheated 120° F. is required, the seeker will find, after turning over many pages, that he has finally to interpolate between four sets of values. He will find the values given for steam at 131.1 lbs. pressure with superheats of 108°.8 and 127°.5; he will also find it for 129.4 lbs. pressure and superheats of 107°.0 and 125°.6. It will consequently be necessary to make three comparatively awkward interpolations to obtain the desired quantity. Of course, if another table is added, the difficulty just mentioned can be overcome, but even then we are no further along when it comes to the solution of problems of another class, such as the throttling of steam. If tables are compiled for all these purposes, the book becomes too bulky.

It is possible to construct a single steam diagram which shall serve the purpose of each kind of steam table to which reference has just been made. The principal disadvantage of a steam diagram lies in the somewhat inferior degree of accuracy which is obtainable unless the diagram is quite large. With diagrams of moderate dimensions it is, however, possible (as will be shown later) to get a degree of accuracy which is amply sufficient for the purposes of the engineer.

There are five principal quantities (or physical coordinates) which may be required and which must be shown on a steam diagram or diagrams in order to permit the solution of ordinary problems. These quantities are (1) pressure, (2) quality (i. e., dryness-factor or superheat), (3) total heat, (4) entropy, and (5) specific volume. If any two of these quantities are known, the remaining three have definite values. Consequently, if any two of these physical coordinates are chosen as the ordinates and abscissae of a steam diagram, each point on the diagram corresponds to steam all of whose physical coordinates are known. If, for example, the ordinates are pressures and the abscissae specific volumes, a particular point representing steam at 30 lbs. pressure and a specific volume of 15.05 cu. ft. will also represent steam with a superheat of 60° F., a total heat of 1192.9 B.T.U. and an entropy of 1.7382. In order to find any one of these other quantities by inspection, it is necessary to draw in a family of curves each member of which goes through all the points on the diagram having some one value of that quantity. If, for example, curves are drawn through all points on the diagram corresponding to total heats of 1,190 B.T.U. and 1,195 B.T.U. the location of the particular point under discussion with reference to these two curves will permit the estimation of the total heat at that point. If all the five physical coordinates are to be read from a single diagram, there must be drawn on that diagram three families of curves; the location of any point with reference to the axes of ordinates and abscissae and to the three families of curves will give the simultaneous values of all five coordinates. The superposition of the three families of curves on one diagram will lead to confusion when the number of curves drawn is sufficient for accurate interpolation, unless the diagram is of large size. It is possible to distribute the curves between two diagrams and so to avoid the confusion.

The choice of the two physical coordinates for ordinates and abscissae respectively, that is, the choice of the *plane* on which the diagram is to be drawn is of great importance in determining the value of the diagram for the solution of problems. With five physical coordinates to choose from, it is possible to get ten different planes on which to plot the diagram. Of these ten planes three alone need be considered: (1) the pressure-volume plane, (2) the temperature-entropy plane, and (3) the total heat-entropy plane.

The *pressure-volume plane* is the best known to engineers; it is the plane on which the indicator card is drawn. Its great value lies in the fact that areas in this plane represent external work. But this is its only advantage. As a plane on which to draw a steam diagram, it is practically useless because vertical and horizontal lines on such a diagram (which are the only lines having constant scales) show only the pressure and volume changes and give no information as to heat exchanges or other important quantities. It is extremely valuable as a plane on which to plot the change through which steam is going when expanding in a cylinder, because it shows how much external work is being done at any time; but it is decidedly less useful than several other planes when used as the basis of a steam diagram.

The *temperature-entropy plane* has been more largely used than any other as the basis of a steam diagram. It makes a useful diagram, though not (as we shall see later) as useful as the total heat-entropy plane. The particular value of the plane arises from the fact that if a line is drawn on that plane representing the series of changes through which a constant mass of steam is going, the heat going to or leaving the steam during those changes is represented by the area between that line and the line of absolute zero of temperature. That is, this diagram permits the determination of the heat flow to or from steam, in a way precisely similar to that in which the pressure-volume plane permits the determination of the external work. As with the pressure-volume plane, the plane itself is most valuable; but a steam diagram on that plane is less useful than a steam diagram on the total heat-entropy plane.

The Total Heat-Entropy Plane.

Before considering the total heat-entropy plane it is desirable to examine the particular properties of total heat. The total heat of unit mass of steam may be defined as its internal energy plus the heat equivalent of the product of the pressure and specific volume, or

$$H = E + 144\ A\ p\ v,$$

where E is the internal energy in B. T. U., A is 1/778, p is the pressure in lbs. per sq. in. and v is the specific volume in cu. ft. As H and E are assumed to be zero for water at 32° F., the value of H for steam is seen to be the total heat which has to be supplied to a boiler in order to convert one pound of water at 32° F. into steam in the condition under consideration.

The total heat of steam is a quantity which enters into a large number of problems. If a pound of steam flows with negligible velocity into any appliance, it will take with it its internal energy E_1, and in being forced in by the steam that follows, it will have an amount of work done on it equal to $144\ A\ p_1\ v_1$. That is, the total energy, neglecting kinetic energy, entering a steam appliance with every pound of steam that flows into it will be $E_1 + 144\ A\ p_1\ v_1$, or the total heat H_1, of the steam. Similarly, every pound of steam leaving an appliance, takes with it its internal energy E_2 and does the work $144\ A\ p_2\ v_2$ in displacing the steam which has preceded it; so that the energy leaving the appliance with every pound of steam (neglecting kinetic energy) is $E_2 + 144\ A\ p_2\ v_2$ or the total heat H_2.

Consequently in any appliance which is supplied with steam but which does not store it up, the total amount of energy which is given up in the appliance by each pound of steam, will be the difference between the total heats of the entering and of the leaving steam, $H_1 - H_2$. The energy so given up may have been abstracted by heat conduction or radiation, may have been converted into work, may have been used in increasing the kinetic energy of the steam, or may have been used in all these ways. The quantity $H_1 - H_2$ is the energy which is available for these purposes and which has to be accounted for in analyzing the performance of any steam apparatus. In a steam engine it is the sum of the work done and of the external heat losses; in a boiler it is negative and represents the heat supply per pound of steam formed; in a non-conducting steam nozzle it is the heat that is converted into kinetic energy; in a perfect throttling calorimeter its value is zero because there is no external work done, no heat conduction, and no change in kinetic energy.

The value of a steam diagram on the total heat-entropy plane may now be seen. On such a diagram the quantity $H_1 - H_2$ is represented by the vertical distance between points representing the conditions of steam entering and leaving any apparatus. Vertical distances measure the energy given up in a steam appliance, with a constant scale all over the diagram. If there is no heat conduction in the appliance, the process there is adiabatic and consequently the steam leaves with unchanged entropy; the points representing the entering and leaving conditions will then lie on the same vertical line. The constancy of the scale of total heats all over the diagram is of particular value in flow of steam problems. The velocity which is acquired by steam in going through a perfect nozzle depends only on the amount of heat which is converted into kinetic energy per lb. of steam, that is, it depends only on $H_1 - H_2$. It is consequently possible to plot a scale of velocities corresponding to different values of $H_1 - H_2$. With such a scale, the velocity acquired by steam in passing through a perfect nozzle can be found at once by transferring the vertical distance $H_1 - H_2$ to the velocity scale. It is in this respect especially that a total heat-entropy diagram is greatly superior to a temperature-entropy diagram.

The large diagram which accompanies this paper is plotted on the total heat-entropy plane. The ordinates are total heats, the abscissae are entropies. Two families of curves are printed in black; the curves which are slightly inclined to the horizontal are in two groups; those below the saturation curve are lines of constant quality (i. e., constant dryness-factor), those above the saturation curve are lines of constant superheat; the curves running diagonally across the diagram are lines of constant pressure. The curves printed in red are lines of constant specific volume. The table printed on the diagram gives the temperature of saturated steam corresponding to each pressure for which a curve is drawn on the diagram, and is intended for use in those problems in which the actual temperature of superheated steam is stated instead of the degree of superheat. The degree of accuracy obtainable by the use of a diagram of this size is indicated by the following test made by the writer on two diagrams from which the present one was arranged. Twelve typical problems of different kinds were given out to each member of a class consisting of ten students who had no previous acquaintance with the diagrams. The solution of the problems (excluding one or two misreadings) showed in one case only an error as great as 1%; the average error was less than four-tenths of 1%; for a large number of the

problems, the error was less than one-tenth of 1%.

The Solution of Problems.

The method of use of the diagram for finding steam quantities is the same in all cases. Two at least of the physical coordinates of the steam will be known in every case. These two suffice to locate a point on the diagram, and the position of that point relative to the axes of coordinates and the members of the three families of curves determines the values of the unknown quantities. The following examples will illustrate the method.

Examples: (1) A vessel of 10 cu. ft. capacity contains 0.1 lb. of water and 0.9 lb. of steam. What is the pressure?

The intersection of the steam quality line 0.90 with the specific volume line 10 cu. ft. is seen to occur at a pressure of 37 lbs. per sq. in. abs.

(2) Measurements from an indicator card show that when the volume of steam is 1.3 cu. ft. its pressure is 80 lbs. abs. If the weight of steam in the cylinder is 0.2 lb. what must be its quality?

The specific volume of the steam is 1.3/0.2 = 6.5 cu. ft. The diagram shows that steam at 80 lbs. pressure with a specific volume of 6.5 cu. ft. has a superheat of 118°.

(3) What is the entropy of 1 lb. of steam at 150 lbs. pressure and a temperature of 450° F.?

The table shows that saturated steam at 150 lbs. pressure has a temperature of 359° F. The superheat is therefore 450 — 359 = 91° F. The entropy of steam at 150 lbs. pressure superheated 91° is 1.629.

(4) What is the heat supply per lb. of steam to a boiler with feed water at 80° F., generating steam at 100 lbs. pressure and superheated 100° F.

The total heat of steam at 100 lbs. pressure, superheated 100° F. is seen to be 1,239.7 B. T. U.; the feed water enters with 80 — 32 = 48 B. T. U. The heat supply per lb. of steam is consequently 1,239.7 — 48 = 1,191.7 B. T. U.

The *internal energy* of steam is found by use of the equation

$$E = H - 144\ A\ p\ v.$$

Example (5). What is the internal energy of 1 lb. of steam at 100 lbs. pressure and a volume of 5.2 cu. ft.?

The total heat of the steam is seen to be 1,244 B. T. U. The internal energy is

$$1{,}244 - 144 \times 1/778 \times 100 \times 5.2 = 1{,}147.7 \text{ B. T. U.}$$

Adiabatic Expansion.—During adiabatic expansion entropy is constant. Vertical lines on the diagram are lines of constant entropy. A vertical line consequently shows the changes in the condition of steam which is expanding adiabatically. In adiabatic expansion problems two of the three quantities, pressure, quality, and specific volume will generally be known at some point on the adiabatic curve. This suffices for finding the entropy.

Examples: (6). Steam at 150 lbs. superheated 120° F. expands adiabatically. Find its quality and the ratio of expansion when the pressure has fallen to 15 lbs.

The entropy of the steam is seen to be 1.645; at 15 lbs. pressure steam of the same entropy has a quality 0.923. The initial volume was 3.6 cu ft., the final volume is 24.3 cu. ft. The ratio of expansion is 24.3/3.6 = 6.76.

(7) Steam at 100 lbs. pressure superheated 90° F. expands adiabatically with a ratio of expansion of 5. What are the pressure and quality at the end of expansion?

The initial specific volume is 5.06 cu. ft.; the final volume is 25.3. The entropy is 1.66. The pressure corresponding to this entropy and the final volume 25.3 is 14.5 lbs. abs., the quality is 0.9325.

The work done during adiabatic expansion cannot be taken directly from the diagram. It is equal in amount but opposite in sign to the change of internal energy during expansion, or $W_{12} = E_1 - E_2 = H_1 - H_2 - 144\ A\ (p_1 v_1 - p_2 v_2)$.

The simplest way of finding the work done is to find $H_1 - H_2$ from the diagram, and to subtract from it the last term in the equation.

Example (8). How much work is done in the preceding example?

The change in total heat, $H_1 - H_2$, is represented by the vertical distance between the initial and final points on the diagram. This, when measured by the scale of ordinates, is seen to be 150.7 B. T. U.

$$W_{12} = H_1 - H_2 - 144\ A\ (p_1 v_1 - p_2 v_2).$$
$$= 150.7 - 144 \times 1/778\ (100 \times 5.06 - 14.5 \times 25.3) \text{ B. T. U.}$$
$$= 150.7 - 26 \text{ B. T. U.}$$
$$= 124.7 \text{ B. T. U.}$$

Work Done in the Rankine Ideal Cycle.—In the Rankine cycle, steam is admitted at a constant pressure, expands adiabatically to the back pressure and is exhausted against a constant back pressure. The engine is supposed to have no clearance. It is an ideal steam engine cycle with no internal friction, no heat losses, and no free or imperfectly resisted expansion. In such a cycle all the energy that is taken from the steam must be converted into work. The work done per lb. of steam is consequently $H_1 - H_2$. As the only expansion that takes place is adiabatic, the entering and leaving steam have the same entropy.

Example (9). Steam initially at 150 lbs. pressure superheated 150° F. goes through a Rankine cycle with a back pressure of 2 lbs. How much work is done by unit mass of the steam?

The change in total heat is seen to be 311 B. T. U. The work done is 311 × 778 ft.-lbs.

The Flow of Steam.—In a steam engine the resistance to expansion is offered by the piston, and the useful work is done on the piston; in a steam nozzle the resistance to expansion is offered by the steam which is ahead, and consequently the work is done on the steam, and results in giving it kinetic energy.

If steam is admitted to a properly designed, non-conducting nozzle without internal friction, it will expand adiabatically. Since there is no heat loss, and no external work done, all the energy that is taken from the steam must be converted into kinetic energy. The kinetic energy of the escaping steam is consequently $H_1 - H_2$. The velocity corresponding to this kinetic energy of unit mass of steam can be read directly from the scale to the left of the diagram. It is evident that the kinetic energy of the escaping steam is equal to the work that would have been done by the steam in a Rankine cycle with the same back pressure.

To find the velocity with which steam escapes from a properly designed frictionless nozzle, measure with a pair of compasses the change in the total heat of the steam during adiabatic expansion and transfer this measurement to the velocity scale.

Examples: (10). Steam at 100 lbs. pressure, superheated 60° F., expands in a nozzle to a pressure of 2 lbs. per sq. in. What is its final velocity?

The change in the total heat is 266 B. T. U. This is seen by the scale on the diagram to correspond to a velocity of 3,650 ft. per second.

(11). A four-stage impulse turbine supplied with steam as in example 10 and with expansion to the same pressure, is designed for equal velocity of steam in each of the stages. What is that velocity?

The kinetic energy of the steam in each stage is 266/4 = 66.5 B. T. U. This corresponds to a velocity of 1,825 ft. per second.

Designing a Nozzle.—The design of a steam nozzle for a desired weight flow is determined by the throat (smallest cross-section) of the nozzle. The pressure at the throat will be about .58 of the initial pressure whenever the ratio of the final pressure to the initial pressure is less than that quantity; for ratios greater than .58 the throat pressure is the same as the final pressure. To determine the throat area, find the velocity and specific volume of the steam at the throat. The specific volume multiplied by the desired weight flow in lbs. per second is the volume flowing per second past the throat. This volume divided by the velocity at the throat is equal to the area of the t[illegible]at, in square feet.

Example (12). Fifty lbs. of steam at [illegible] lbs. pressure, superheated 100° F., flow per [illegible]inute through a nozzle into the atmosphere [illegible] lbs. per sq. in.). What is the smallest cross [illegible]ction of the nozzle?

The entropy of the steam is 1.629 and i[illegible] total heat 1,251 B. T. U. At the throat the pre[illegible]re is approximately 160 × .58 = 92.8 lbs. per [illegible] in.; the total heat is 1,202 B. T. U., and the [illegible]cific volume is 4.98. The kinetic energy at the [illegible]roat is 49 B. T. U., which corresponds to a [illegible]elocity of 1,575 ft. per second. The volume flowi[illegible] per second past the throat is 50/60 × 4.98 = [illegible] cu. ft. The throat area is consequently 4.15/[illegible].575 × 144 = .380 sq. ins.

Throttling.—If steam expands through a small orifice (or a porous plug) without the addition or abstraction of heat, and is brought finally to its initial velocity, its total heat will be unchanged. This must be the case because none of the heat is converted into external work or kinetic energy, and no heat is added or abstracted, so that $H_1 - H_2 = 0$. The process is called throttling, and occurs when steam goes through a reducing valve and also in the throttling calorimeter. Horizontal lines on the diagram are lines of constant total heat and consequently show the changes in the condition of steam which result from throttling.

Examples: (13). Steam at 200 lbs. pressure, quality 0.99, passes through a reducing valve. At what pressure must the valve be set in order to discharge dry and saturated steam?

Inspection of the diagram shows that dry and saturated steam at 119 lbs. has the same total heat as steam at 200 lbs. and quality 0.99.

(14). Steam in a throttling calorimeter has a pressure of 17 lbs. per sq. in. and a temperature of 265° F. The initial pressure of the steam was 100 lbs. per sq in. What was its initial quality?

Saturated steam at 17 lbs. has a temperature of 219° F.; the superheat in the calorimeter is consequently 265 — 219 = 46° F. The initial quality of the steam is seen by inspection to be .987.

Hirn's Analysis.—In making Hirn's analysis of the performance of a steam engine it is necessary to find (from the measured pressure, volume, and weight of steam acting) the internal energy of the steam in the cylinder at admission, cut-off-release, and compression. These quantities are readily found by the method already outlined.

Temperature-Entropy Diagram.—In redrawing an indicator (pressure-volume) diagram on the temperature-entropy plane, the assumption is made that the whole of the working substance remains in the cylinder throughout the cycle, and that heat is added to and abstracted from it while it is in the cylinder. That is, the boiler, cylinder, and condenser operations are all assumed to take place in the cylinder. It is most convenient to draw the diagram for unit mass of steam, which is readily done after determining the proper scale of volumes for the indicator diagram. The process then becomes extremely simple: the temperature and entropy corresponding to a series of points on the indicator diagram are found and are plotted. It should be noted, however, that the diagram does not give information for qualities below about 0.8. Consequently some of the points on the temperature-entropy diagram must be calculated.

Other Problems.—Many special problems of less common occurrence than the foregoing can be easily solved by the use of the diagram. For example, suppose it is proposed to spray into a gas-engine cylinder a certain weight of water at a certain instant, and it is desired to know what will be the resulting pressure and temperature in the cylinder. The partial pressure, temperature and total heat of the steam formed will be represented by the coordinates of some point on a definite constant specific-volume line; the exact position of the point on the line is fixed by the conditions of the problem; the solution is found by a process of trial and interpolation.

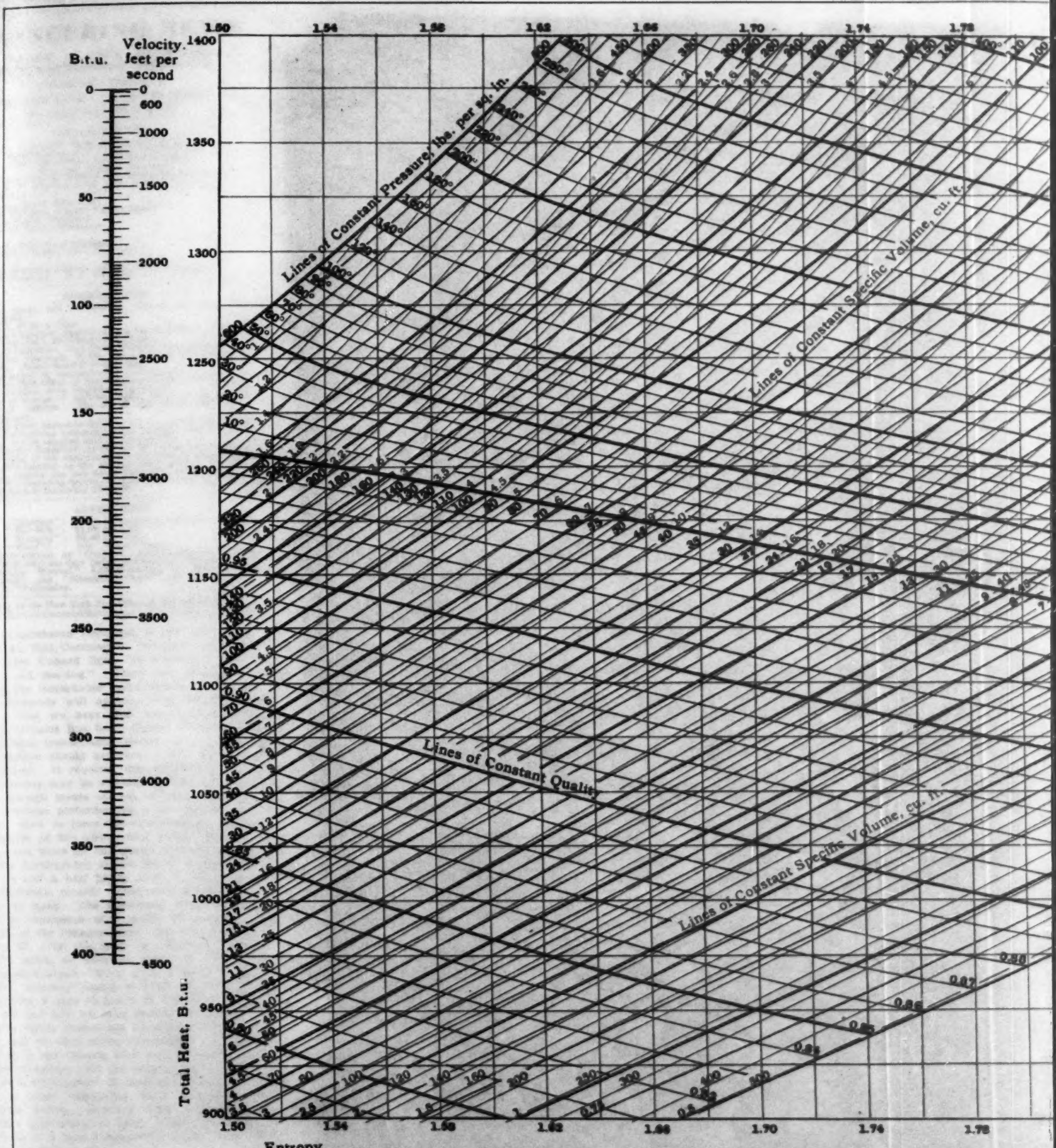
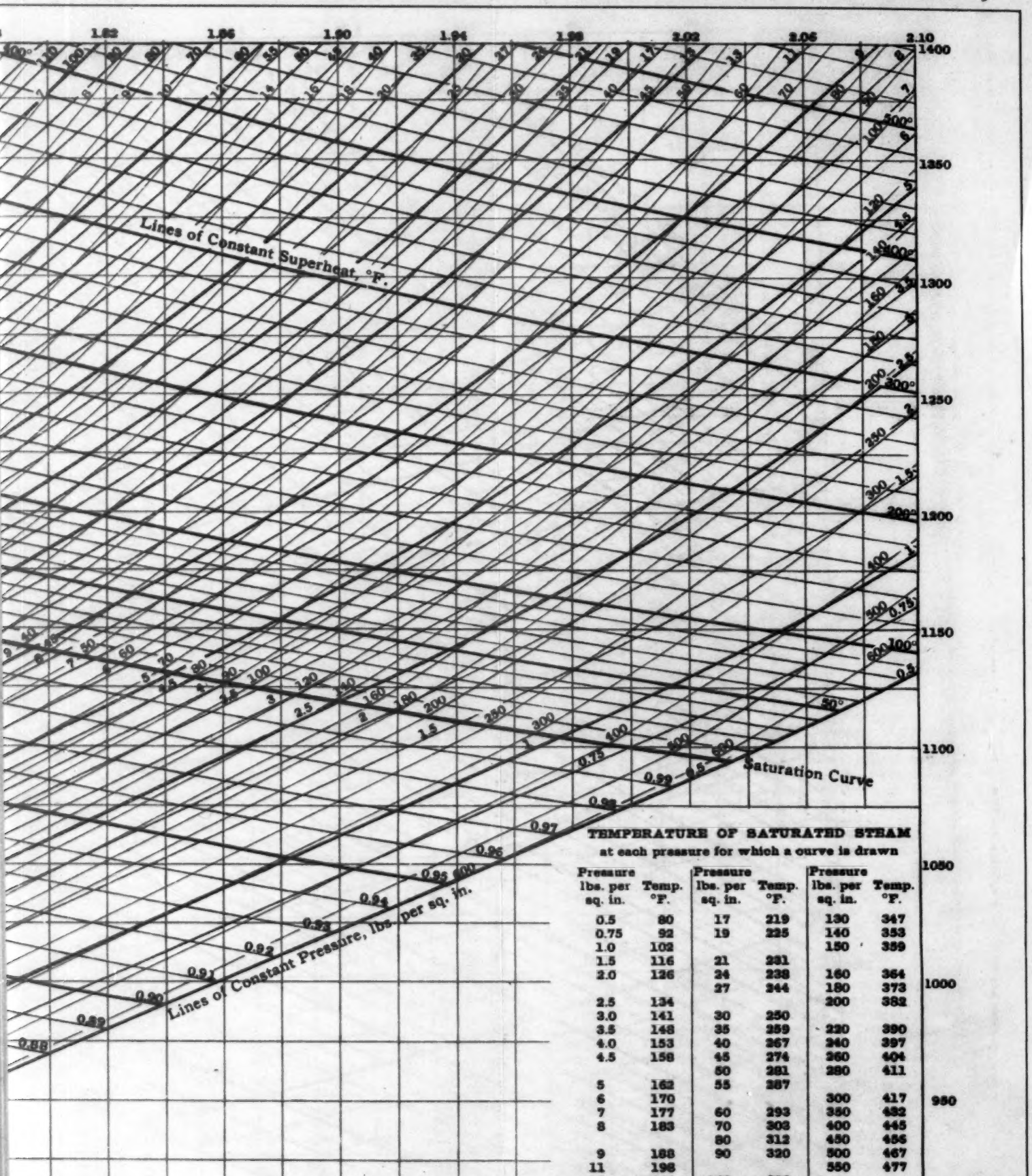


DIAGRAM OF TOTAL HEAT ENTROPY FOR THE SOLUTION OF STEAM PROBLEMS

Accompanying "The Solution of Steam Problems by the Us

Compiled from large diagrams accompanying "Steam Tables and Diagrams," by Marks and Davis,

(Ordinates are Total Heats, Abscissae are



TEMPERATURE OF SATURATED STEAM
at each pressure for which a curve is drawn

Pressure lbs. per sq. in.	Temp. °F.	Pressure lbs. per sq. in.	Temp. °F.	Pressure lbs. per sq. in.	Temp. °F.
0.5	80	17	219	130	347
0.75	92	19	225	140	353
1.0	102			150	359
1.5	116	21	231		
2.0	126	24	238	160	364
		27	244	180	373
2.5	134			200	382
3.0	141	30	250		
3.5	148	35	259	220	390
4.0	153	40	267	240	397
4.5	158	45	274	260	404
		50	281	280	411
5	162	55	287		
6	170			300	417
7	177	60	293	350	432
8	183	70	303	400	445
		80	312	450	456
9	188	90	320	500	467
11	198			550	477
13	206	100	328		
		110	335	600	487
15	213	120	341		

BLEMS SHOWING PRESSURES, QUALITIES AND SPECIFIC VOLUMES

the Use of a Diagram," by Prof. L. S. Marks

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An Englishman remarked, a year ago now it must be, that Commodore Pritchard, captain of the great Cunard liner "Mauretania," was "a crafty old sea-dog." Every one who has followed the remarkable performances of the ship he commands will approve that remark, but, every time we hear that ten, or twenty, or thirty minutes has been clipped off some just-established transatlantic record, we feel that the Commodore should get some credit as a clever advertiser. It requires fine judgment, if mere landlubbers may be allowed to think so, to put just enough stress on his organization to clip his previous performances a few minutes at a time. How to force the equipment so that the reduction of five and a half hours yet possible shall not come as one grand surprise, seems a subtle development of the art of seamanship.

Five and a half hours more to come off the transatlantic record! That may sound improbable to many. The statement, however, is the logical conclusion of a study of the performances of the "Mauretania." On the trip ending June 21, over the long, or "winter" course of 2,934 miles, an average speed of 25.88 knots was maintained. With such a speed over the short "summer" course of 2,783 miles the record will read 4 days 11 hours 30 minutes. But that is not the best we may expect. A speed of 26 knots seems within the capabilities of the vessel and the skill of its commander. A speed of 29 knots has already been kept up for 200 miles, and we believe that the skipper can hold to that a little while longer at each end of some voyage, when other expedients have been exhausted. These spurts, combined with a speed of 26 knots maintained at other times, will give the record of 4 days 9 hours—5½ hours better than has yet been done.

There is little danger of seeing the world startled by this reduction all at once. Considering the skipper's new art, some 15 or 16 new records are possible and, as these must be over the short "summer" course, there is a good five years' supply of mid-summer advertising on hand. Then, too, the sister ship "Lusitania" may come out of the shadow. We are told that she has been equipped with new propellers of the type found so efficient on the "Mauretania." If her captain is as skillful a mariner as Commodore Pritchard, we may be treated to the rare spectacle of seeing the "blue ribbon of the seas" alternately passed between these boats three or four times a year. By the time the record of 4 days 9 hours is reached will the "trophy" be badly tattered and torn?

The outlook for needed reforms in designing and operating furnaces for burning city refuse in American cities is increasing with each of the new installations conceived along the lines of the best and latest engineering practice. A hopeful sign of the times is the fact that American engineers are not only receiving encouragement from American cities in their study of European practice, but that in these foreign studies our engineers are now beginning to go beyond superficial surveys of the field and are taking up details of construction and operation. Some of the results of the most recent study of refuse-destructor practice that has come to our notice are given elsewhere in this issue. They relate to the methods employed in charging refuse into high-temperature incinerators. Comparisons are made of mechanical and hand-firing methods, and deductions are drawn as to the relative economy and efficiency of each method.

We leave to others, and particularly to those who have been intimately connected with the design and operation of refuse destructors, the discussion of Mr. Greeley's conclusions, with this exception: it seems to us that perhaps Mr. Greeley has somewhat over-emphasized the sanitary advantages of not having refuse exposed to view or to the air of the destructor building. It seems to us questionable whether any considerable expense is warranted for the sake of preventing such exposure. It is of course very proper to consider the comfort of the workmen and their exposure to dust and dirt and their possible remote danger of infection. Aside from this, the chief consideration, so far as the public health is concerned, in comparing the relative advantages of charging systems which do and which do not expose the refuse, would seem to relate to first cost, capital and operating charges.

The French Panama Canal companies excavated about eighty million cubic yards during the three decades prior to the American occupation in 1904. During the past month the record of American excavation reached and passed this figure. The occasion marks something of an epoch in the history of the canal.

The material dug out by the French was mostly earth, and they worked chiefly at those points where conditions were favorable to low cost per cubic yard and large output. The U. S. Government forces have been working at greater depth, largely in rock, and all along the line without selection of special points for a record. Each cubic yard of the American excavation therefore represents more work and more achievement than a cubic yard of the French. The actual figures show that the French total was equaled in the time from May, 1904, to August, 1909—five and a quarter years; in view of the differences in character of work, however, we may safely round off the period of equal performance to five years. The French, during their thirty years' occupation, were at work some twenty years. The present American attack therefore has taken just about one-fourth as long as the French attack, for equal performance.

The French public, which furnished the money for the work of the Panama Canal Companies, lost confidence in the enterprise through discouragement. Years were passing, and though the work was progressing its progress did not seem to bring the final completion of the project measurably nearer. The sources of money-supply dried up, and in the end the assets had to be sold at a sacrifice; sold far below their cost, and well below their value. The American authorities, who found it possible to use only half the total French excavation, consider that even this was worth more than was paid to the French owners, and the old plant, Panama R. R. rights, etc., are in effect thrown in for good measure.

The intensely rapid progress of the American work at Panama is an effective protection against a similar loss of confidence in this country. The progress has been such as to give promise of final completion within six years more—a period not so remote as to kill off the enthusiasm of the people of the United States, who pay the cost. Evidently, rapid work is worth while, even at increased cost. What would be the popular feeling about the canal if the American forces had taken until 1924 to equal the French output?

The Merchants' Association and some of the newspapers in New York City continue to make themselves ridiculous by their absurd utterances regarding the sewage-disposal problem of the New York and New Jersey metropolitan districts. Perhaps they should be excused for some of their more recent absurdities, in view of the fact that this is the proverbial season for midsummer silliness.

The latest of many foolish utterances on the part of the Pollution Committee of the Merchants' Association is its attempt to make out that the United States government ought to and could collect from New York City cumulative penalties to the gross amount of $66,000,000 for the discharge of sewage into navigable waters without first having obtained a permit from the government. This claim appears to be based on United States statutory requirements that no refuse shall be discharged into navigable waters without first obtaining a permit from the War Department. New York City having some hundreds of sewer outlets into navigable waters, for none of which it has obtained a permit, and these outlets having been discharging sewage for considerable periods, it is of course possible to figure up a large total of fines against the city. But why should the government institute proceedings of this sort against New York City alone? Almost without exception, every city in the United States is discharging its sewage into navigable waters, if it is so fortunate as to be situated upon such, and so far as we know not one of the cities has ever secured a permit for that purpose from the government. Some of them may have applied to the War Department for a permit to build outlets which, as engineering structures, might obstruct navigation, but that is all. The facts of the case seem to be that the statute in question was never designed to prohibit the discharge of sewage. If we mistake not, it has been so interpreted either by the courts or by some of the high law officers of the United States government.

The only possible justification we can see for this latest anti-pollution move on the part of the committee of the Merchants' Association, is that only by attempting to outdo Judge Landis in his $29,000,000 Standard Oil fine could public attention be centered on the work of the committee. Thus far, neither the responsible officials of New York City, nor any considerable proportion of either its taxpayers or citizens, appear to have shown any marked interest in the efforts of the Merchants' Association committee to direct attention to the pollution of the waters surrounding New York. We think the reason for this is that the agitation has been so sensational and so little guided by technical considerations as to make no serious impression.

We do not deny that serious attention ought to be given to the question of proper means of sewage disposal for the New York and New Jersey metropolitan districts. We think, however, that more harm than good will come from such sensational and ridiculous agitation as has been conducted by the Merchants' Association committee, and we are surprised that the sagacious business men in that association do not see how ridiculous the association is being made by allowing its name to be coupled with the crude ideas of the promoter of the agitation. We are even more surprised that such a man as Mr. J.

Pierpont Morgan should continue to allow his name to be used to give ballast, as it were, to the committee and to attract the public eye to its voluminous sensational utterances.

As to the ridiculous part some of the daily newspapers of New York have played in this affair, it is of course useless to say much. They are not and perhaps cannot be informed on all the many technical subjects which they feel called upon to handle in their news columns. It would seem, however, that in such of their editorial comments as do not by the exigencies of news demand haste, they might avail themselves of technical advice. If this were done we should not expect to see such a sentence as the following, which appeared in a recent issue of the New York "Times": "Why is New Jersey so blind to its own interests as not to perceive the magnificent opportunity there is to fertilize waste meadows with the sewage nuisance?"

What a grand thing it would be if only nuisances could be utilized as fertilizers! We see no reason why such a plan would not be quite as economically and technically practicable as getting fertilizing value out of sewage by applying it to water-soaked salt marshes. We shall expect to see both accomplished about the time that the U. S. Government collects $66,000,000 of water-pollution fines from the city of New York.

Calling attention to the fallibility of the reports of engineering matters in the daily press is a thankless as well as endless task, but occasionally a peculiarly flagrant misrepresentation must be corrected, not only for the sake of the truth, but also to remind the public of this tendency toward inaccuracy in reporters. Of such nature is the incident recorded below, one column from a dispatch to the New York "Sun," the other from a letter from Mr. H. N. Ruttan, the City Engineer of Winnipeg:

N. Y. "SUN," AUG. 17, 1909.	LETTER FROM CITY ENGINEER RUTTAN AUG. 21, 1909.
Winnipeg, Aug. 16.—The reinforced-concrete apartment block known as the Breadalbane, being erected in Hargreave St. at a cost of $250,000, fell in with a crash last evening. Heavy rains had moistened the concrete so that the steel girders gave way, sending down the weighty floors to the basement. Four workmen were crushed, two so severely that they may die.	The accident to the "Breadalbane" apartments followed a very heavy rainstorm and consisted of a slight cave-in of the concrete foundation wall, presumably due to water getting in and undermining it. The damage was slight, the building not being built above the foundation walls. A workman or two are reported to have received slight injuries.

The destruction of the wireless-telegraph station of the Marconi Company at Glace Bay, Nova Scotia, has stopped the transmission of transatlantic messages for several months. A survey of the conditions under which the disaster arose shows that a marked disregard of a few recognized engineering principles, paved the way for the embarrassment and temporary lack of prestige which this company now faces. High-tension electrical apparatus of considerable energy capacity was housed in wooden shacks located beyond the reach of any local fire department and evidently were equipped with no adequate private means of fighting fire under the peculiar conditions prevailing. The whole arrangement seems to have been temporary, though the service was advertised as permanent. Yet here was housed and used thousands of dollars worth of apparatus, of which there was no duplicate and upon which the continuity of the assumed public service depended. The combination of light inflammable structures, lack of fire protection and lack of duplicate apparatus might have been expected to be too much for reliable service. The critics of this transatlantic service have been numerous, particularly on the other side of the ocean. One might have supposed that their criticisms would have led the operating company to be alert, and one may now believe that the other wireless concerns will see where their own plants need inspection.

The importance of wireless telegraphy to maritime service demands that all possible safeguards be sought for continuity of service at important shore stations.

Machinery for Canal and Ditch Excavation.

The development of machinery for the excavation of material in construction works, and for the handling of the excavated material, has been one of the marked features of American practice in the execution of public works, and the development continues as new conditions present requirements or possibilities for special machines. The objects are threefold: (1) to improve the facility and rapidity of executing the work; (2) to reduce the cost of the work, and (3) to reduce the labor troubles which attend work requiring the employment of large gangs of men, especially where the work is at a distance from centers of population. Many special forms of excavating machines and conveying appliances have been put in service for special classes of work, while various modifications in machines of ordinary character have been introduced to adapt them to special conditions. Opportunities for further development in this direction appear to be offering at the present time.

The building of the Chicago drainage canal exerted an important influence in this direction, with the result that this work marked a distinct line of progress in high speed and low cost of excavation. Many special machines and appliances were designed and tried, more especially for the handling of material, and while some of these proved to be more or less unsatisfactory the net result was a marked improvement upon previous work of a similar character. New machines and methods have been introduced also to some extent on the New York barge canal, now under construction, but the results have not represented a general advance in records of excavation, largely for the reason that the conditions are more diverse than at the Chicago drainage canal, which involved mainly the excavation of a continuous channel in rock and dry earth. Dredging and rock excavation are not included in the character of the work which we have now under consideration, but these might be made the subject of separate investigation.

The development of excavating machinery and equipment in the case of the Chicago drainage canal applied more particularly to work on a large channel, where machinery of extensive character and high cost could be installed with advantage. The construction of many hundreds of miles of canals for irrigation and drainage projects, now in progress and in contemplation, suggests the idea that this work may influence a development in machinery of a simpler character, adapted for the rapid and economical excavation of canals of the smaller class, including those which are commonly known as ditches. Various methods and machines are being used by engineers and contractors on the main and lateral canals of the government irrigation work, but so far as we know the machines include none of special design or which differ distinctively from machines previously used. In a recent letter from one of the engineers of the U. S. Reclamation Service we find the following statement, which we commend to the attention of those of our readers who are interested in excavating machinery, whether as manufacturers, engineers or contractors:

> On some of the larger canals the contractors tried elevating graders drawn by traction engines, but this method was a failure in sandy material. A road grader was tried on the excavation of small laterals, and where the cut was from 6 ins. to 2 ft. and the material was damp this was an improvement over scraper work. Like many other engineers I am looking for a cheaper method of handling ditch excavation than teams and scrapers; I believe a machine will be invented to do it, but so far have seen none that proved a success, at least under our conditions.

The excavating machinery employed on the irrigation canal work includes elevating graders, steam shovels, scraper-bucket derricks, and different kinds of grading machines. One objection which has been made to the first-named machines, especially for work in the arid regions and in unsettled country, is the large number of horses required for each machine. Traction engines have been tried for hauling the graders, but in some soil they do not pull well, while in other cases they pack the soil so hard that it is difficult for the machine to plow it, the result being that the progress is so slow as to make the method uneconomical. It is to be remembered that on this irrigation work many special conditions are encountered, and it is well known of course that the elevating grader is a well established machine with a long record of usefulness.

A very considerable proportion of the smaller canals, laterals and ditches of the irrigation work have been excavated by teams and scrapers. The scrapers used are of various kinds, including slip or drag scrapers, wide-mouthed box or Fresno scrapers, and wheeled scrapers. One of the special advantages of scraper work is its flexibility, or its adaptability to varying conditions and various sizes of channels. It can be used where the channel is wholly in excavation or in embankment, and where it is a combination of both, as in sidehill work. In building canal embankments, also, the tramping of the teams is of importance in consolidating the material. Furthermore, the earth can be excavated from and deposited at any desired point within a considerable range.

Much of the irrigation canal work, however, is done in a hot and dry country which is remote from settlements and from permanent bases of supply. Under such conditions not only is there difficulty in getting and keeping a force of men (many of the men staying but a short time and then drifting away to other work), but the maintenance and care of a large number of teams involves trouble and expense. The result is that the contractor (or the engineer on the day labor system which represents a large part of the irrigation work), cannot count on organizing and maintaining his force and outfit for the most economical work. It would be of advantage, therefore, if some means could be found for reducing the large number of men and teams required for a grading outfit. This has been made possible to some extent by the introduction of wheeled scrapers of much larger capacity than those usually employed. But there is evidently a field open for the introduction of excavating machinery specially adapted to work of this kind.

In view of the successful development of self-propelled vehicles, and of their reliability under extremely severe conditions of service imposed by bad roads, careless operators and heavy loads (as in motor wagons), it seems possible that a large self-propelling scraper may perhaps be designed to meet the conditions which we have noted above. Of course there are no roads, but we believe that motor-cars in military service have been at least fairly successful in cross-country work, and wheeled scrapers are operated easily enough in rough country, while to a large extent they work on their own beaten tracks. At any rate the possibilities are worth considering.

It is needless to say that such a machine must combine lightness and strength, and that its mechanism must be "fool-proof" and able to stand very rough usage. A machinist and blacksmith could attend to the maintenance and repair of an outfit of motor scrapers as easily as a stable boss, horse-shoer and gang of helpers can attend to the feeding, shoeing, harness repairs, and the occasional ailments of an outfit of horses.

Mention has been made of drainage canals. These are usually in moist ground and in districts nearer to towns or centers of population. Scraper work is largely used, and different designs of land and floating dipper dredges, together with special machines of a type noted below. In swampy districts also, suction dredges of the smaller class are used, but we are now considering mainly dry excavation.

One of the special lines of development in excavating machinery, in which there has been very great activity during recent years, is in trenching or ditching machines, and these are now in very extensive use. They are employed mainly for two classes of work: (1) in the laying of sewers, water and gas mains, etc., in towns and cities; (2) in the laying of tile drains for land drainage and reclamation. They do the work more expeditiously than gangs of men, they cut narrower trenches than is practicable to cut by hand (for any great depth), and they ma-

terially reduce the importance of the labor problem as related to the execution and cost of the work.

The machines are self-propelling, and have usually either a vertical circular revolving frame fitted with buckets or a ladder frame carrying an endless chain fitted with cutters, scrapers or buckets of various forms. The ladder or circular frame lies in the trench (being adjusted to the required depth and grade), and the cutters or buckets excavate the material from the face as the machine moves forward. The material is delivered upon lateral conveyors which discharge it upon the ground for backfilling or into wagons for removal.

For both of the classes of work noted above the excavation is a narrow trench with vertical sides, and this is backfilled of course as soon as the pipes are laid. There are, however, modifications of machines of this class which are adapted to cutting open ditches or canals with sloping sides. Practically all of the machines are designed for working only in full excavation, and are not generally applicable for the side-hill or embankment work which is required to a large extent in the construction of irrigation canals. Nevertheless, this type of machine offers opportunities for application to work of this particular kind.

Another special type of excavating machine which may be mentioned is the power scraper-bucket machine. This is of quite recent introduction but has been applied extensively to work of various kinds. Machines of this type would seem to be adapted to small canal and open ditch work, and in fact they have been used on some of the larger channels of irrigation systems.

These machines may be divided into two classes: (1) with the bucket handled by lines from the boom of a traveling derrick; (2) with the bucket handled by lines from a stationary engine. In either case, the scraper bucket is attached to cables forming a circuit, so that it can be hauled in either direction, the cut being made on the forward travel (towards the engine). In machines of the first class, the back-haul cable is led over the end of the boom, while in those of the second class it is led through a snatch-block anchored at the limit of travel. In a modification used on the New York barge canal, the cables do not form a circuit, and only the hauling cable is attached to the bucket. The other is a fixed cable led from the engine over a tall tower and down to an anchor, but one end is attached to a drum so that it can be made taut or slack as required. The bucket is suspended from the fixed cable, and when dumped it runs by gravity down this cable to the anchor. The fixed cable is then slackened to allow the hauling cable to pull the bucket along the ground while it makes its cut, when the fixed cable is tautened and the bucket hauled up to the dumping point.

In recent developments of scraper-bucket machines of the first class, the bucket is handled by a locomotive crane (traveling on a construction track) or by a traction engine fitted with a boom for this purpose. Such machines may move with fair speed and can travel therefore between the points where the material is excavated and deposited, instead of being limited to the reach of the boom. For some classes of canal work, therefore, they have advantages in greater portability and wider range of action than machines in which the buckets are handled by the booms of slow-moving derricks (mounted on rollers) or by cables from stationary engines. In regard to operation by stationary engines, also, it is to be noted that the range of action may be greater than where a boom is employed, but for light work it will involve rather frequent shifting of the cables, anchors and guide sheaves.

The trenching machine and the scraper-bucket machine, of course, are but two of the many developments in excavating machinery, and we mention them specially for the reason that they represent almost distinct types of machines, rather than modifications of other machines. To describe adequately all the various machines, and their conditions of working would require a book of no small size. Our purpose in the present case is not to deal with such machines in detail, but rather to point out some of the general lines of development and to suggest some possibilities of further development in the line of canal excavation.

It might seem at first, that the steam shovel would meet the requirements, but it appears that much of the work under consideration is too light to make it economical to transport and operate such machines. The steam shovel, also, is generally economical only in work which presents a fairly deep cut. It is to be noted, however, that certain designs are claimed to be specially adapted for light work, even for cuts of only 12 to 18 ins. A light and compact machine of this type might prove of advantage on canal or ditch excavation.

Grab buckets handled by traveling derricks might be applicable under certain conditions, but are not generally adapted for a wide range of conditions. On the New York barge canal there is a machine resembling the familiar coal and ore-handling bridges at large steel works and coaling plants. The traveling bridge spans the excavation and the loaded grab bucket is run out on the cantilever extensions to dump its contents into cars. Such a machine is adapted only for large work.

Reference has been made already to the handling or removal of excavated material, and this is as important as the excavation itself. In some cases the material may have to be dumped directly on a waste bank or placed in an embankment, while in other cases it may have to be removed for some distance. For steam-shovel work, dump cars or traveling tipples may be used, and elevating graders may deliver the material into wagons. The Chicago drainage canal work was specially favorable for the introduction of elaborate conveyor methods, owing to the extent of the work and the quantity of material to be handled. In some of the larger irrigation canals, the steam shovel has been served by a traveling dump, having two cars operated by a cable and running on an inclined track whose lower end is within reach of the dipper while the upper end forms a tipple over the line of the spoil bank.

For the excavation on the smaller canals, however, it is doubtful if it would pay to install conveyor systems. Reliance is there placed largely on the scraper system for both excavating and conveying, or in some cases with an auxiliary wagon haul, the wagons being loaded by dumping the scrapers through traps in elevated platforms.

In the excavation of the canals of the class here considered, it is most desirable to give an even grade, with smooth surfaces for the bottom and the side slopes. This is an important factor to be taken into consideration in the application of machinery to this class of work. In view of the large amount of irrigation and drainage work to be done during the next few years it appears that engineers, contractors and manufacturers may profitably devote attention to the development of special machinery and appliances for excavating canals and ditches effectively, rapidly and economically.

LETTERS TO THE EDITOR.

More Deep Drill-Holes.

Sir: In your issue of Aug. 12, 1909, p. 167, in a paragraph relating to a 3,265-ft. drill-hole the statement is made that "It is claimed that this is the deepest drill-hole ever made in North America." In the West Virginia Geological Survey Report on "Ohio, Brooke and Hancock Counties," 1906, p. 248, occurs the following statement:

> The deepest boring made in West Virginia is the Boggs Run well, three miles below Wheeling, drilled by the Wheeling Development Co., and a careful record was preserved by J C Bardy, Secretary of the company. This well was 4,500 ft. deep, and very careful tests of temperature were made by Dr. Hallock of Columbia University, New York. He found a temperature of 110.3° F. at the bottom, while the top was 51.3°, an increase of 1° F. for every 76.3 ft., though in the lower half of the well the increase was 1° F. for every 60 ft.

Accepting 1° increase for each 60 ft. in the lower half, and correcting the average in compliance with this assumption the increase in the upper half of the hole would be about 1° F. for each 100 ft.

To your added note that there was a 3,200-ft. hole reported in Bisbee, Ariz., you might add that in Canton, Ohio, there is a 3,250-ft. hole and another in Mineral, Athens Co., Ohio, 3,253 ft. deep.

Yours truly, T. H. Loomis.

Steubenville, Ohio, Aug. 16, 1908.

Elastic Limit or Yield-Point?

Sir: While reading with much interest the article entitled "Elastic Limit or Yield-Point as Guide for Working Stresses?" in your issue of Aug. 5, the writer came to the same conclusion as the author, namely, to attach chief importance to the yield-point as was done formerly.

Is this not, upon second thought, an error which is commonly made? Taking the moderately conservative assumption of 16,000 lbs. working-stress on steel, and reflecting that structures designed on this assumption have done all that was expected of them, are we justified in our assurance that this is always adequate?

In the ordinary life of a bridge, or other steel structure, the material may have not had time to receive the fatal number of repeated applications of stress which would cause any of its parts to fail. If we knew definitely what number of repetitions of the assumed stress would cause failure, and knew definitely the number of repetitions of this stress which the parts would receive during the lifetime of the structure, we could tell pretty closely what factor of safety we had in this direction. But materials vary, and the lifetime varies, and to argue that a thing has been done before is not honestly stating that it can always be done. Some contingency may arise which might have been provided against by more conservative assumptions or by a better knowledge of the actual properties of the material.

Take reinforced concrete, for example. Here it is customary to use steel at the same 16,000-lb. working-stress as is used in structural steel, which latter, because it has not so good protection against corrosion, can have nowhere near the same serviceable length of life. If experiment should show that the limit of endurance under repeated stress is located with reference to the "limit of proportionality," and steel is used whose "limit of proportionality" is at 27,000, then for a factor of safety of 2 we should be compelled to limit the working stress at 13,500 lbs.

It would not take very long to determine how the limit of endurance is located, and before erecting costly reinforced-concrete structures which are to endure for, say, double the lifetime of ordinary steel structures, it would be expedient to find by experiment what is the true gage-point in fixing working stresses of steel in tension and concrete in compression.

Very respectfully,

H. F. Tucker.

Culebra, C. Z., Aug. 14, 1909.

Lateral Strength of Top Flange in Tests of I-Beams.

Sir: In the paper on "Bending Tests of I-Beams," reprinted in your issue of Aug. 12, Prof. Edgar Marburg seemed to find that the elastic limit of steel in full-size beam tests is very low; and, according to a note in your report on the meeting of the American Society for Testing Materials (Engineering News, July 8, 1909), while objection to the long unsupported top flanges was made on the floor, both Prof. Marburg and Prof. A. N. Talbot asserted that lateral support is of no influence until the elastic limit is well past. It is further stated in your note that the aforesaid objection does not weaken the showing of the tests that I-beams in full-size test have a very low elastic limit.

I take issue with the statement of Profs. Marburg and Talbot referred to and with the other statement that the objection to the unsupported flanges does not weaken the showing of the tests that I-beams in full-size test have a very low elastic limit.

The ratio of slenderness of some of these beam flanges was nearly 200. I have shown, in a paper in the "Railroad Age Gazette," July 2, 1909, that the ultimate strength of a steel column whose ratio of slenderness is 170 is only 10,000 lbs. per sq. in., even though the column be made of steel having an elastic limit of 100,000 lbs. per sq. in. or an ultimate strength many times this. If the slenderness or unsupported condition of the compression flange of these beams has no influence until the elastic limit is well past, what becomes of the elastic limit of such a column? Also how could any column, however slender, fail at units below the elastic limit of the material?

The webs of these beams and the blocks supplying the load aided in holding the top flange in line, and the tests show to what extent these will offer aid; but the results by no means prove that the elastic limit of steel in a properly braced beam is any such absurd figure as 11,000 lbs. per sq. in.

It is probable that the reading of the elastic limit was the ultimate strength of the compression flange as a spring, and the modulus of rupture was the ultimate

crushing strength of this crippled flange aided by the web.

The fact that high beams showed a low elastic limit is just what might be expected. The web would have less stiffening effect in a high beam than in a low one, and in all of these beams the ends of the compression flange were free except for the stiffness imparted by the supported bottom flange through the web.

These tests are far from being grounds for apprehension on account of the present method of designing beams.

Yours very truly,

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., July 12, 1900.

[The proof to which reference is made consisted merely of the application of Euler's formula $p = \pi^2 E r^2/l^2$. This, of course, applies to freely turning ends. Any tendency toward support of ends or intermediate parts would increase the value 10,000, up to 40,000 as a maximum for fully restrained ends. Prof. Talbot's and Prof. Marburg's remarks were based on the practical absence of lateral deflection of top flange up to and beyond where increase of vertical deflection marked the "elastic limit" of the beam. Failure by buckling in the sense of Euler's formula would be very obvious to the eye.

Several other elements affect the possibility of column action in the top flanges of the beams tested by Prof. Marburg. Instead of bearing their total load at the ends, these flanges received their load all along their length in the case of center load, and all along the outer 5-ft. portions in the quarter-point tests. This raises the buckling limit. Further, the length-ratios were not so extreme as suggested in the above letter. In the case of the 30-in. 175-lb. beam, span 20 ft., flange width 12 ins., which showed lowest elastic limit, the flange by itself has a transverse radius of gyration of 3.1 ins. Thus, for the full 20-ft. length the slenderness ratio would be less than 80, while for the length between load points it would be only about 35. The buckling limits for such lengths are very far above the observed values of elastic limit, even disregarding any stiffening action of the web.

It is a legitimate question, of course, how much lateral support was afforded by the loading blocks, which involved a number of rocker faces at different levels; rather it is a question whether this arrangement may not have favored lateral deflection rather than stiffened the beam against it.

However, there is convincing evidence against any buckling at low unit-stress in the fact that the extensometer readings on opposite sides of the upper flange were in close agreement throughout the range of observation. This supports the statement that no lateral deflection was observable, by the wedge measurements described in the paper, until well beyond the point where the vertical deflections changed rate, and often until near the ultimate strength.

Attention is also directed to the low values of elastic limit found in many of the tensile specimens.

We point out these facts because we feel that the flange-buckling explanation offered is hardly tenable, but that the phenomena and figures reported by Prof. Marburg are greatly in need of confirmation or disproof by other tests, on account of the importance of the issues involved.—Ed.]

The Matter of Efflorescence on Concrete Walls.

Sir: In your editorial on the subject of the Attleboro concrete stand-pipe in the issue of Aug. 19, 1900, p. 202, you say "As . . . efflorescence is almost certain to form on the face of thin water-retaining concrete walls it is almost useless to attempt a treated surface for concrete stand-pipes." This seems to indicate that you regard the efflorescence as the result of seepage through the body of concrete due to insufficient mass, although it may mean that you regard as hopeless the prospect of getting concrete builders to do good work.

I think that in either case you are wrong. So far as I have been able to determine, efflorescence occurs only where there are ununited surfaces, either voids in the body of concrete or mortar, or imperfectly adhering joints between concrete layers or between bricks and mortar. The photograph illustration of your article describing the present condition of the stand-pipe in question shows the whiteness proceeding from either lines or points—evidently not from merely porous areas. If the wetted surface can be made impervious—sufficiently dense to resist seepage under the pressure to which it may be subjected, then there must be faulty workmanship if the white salts are brought to the outer surface, whether it be by moisture from inside or absorbed rain evaporating. I believe that competent and unremitting supervision can secure a grade of concrete in walls that will be both impervious and jointless, and if jointless then not subject to the white blotching, and this without regard to the thinness or thickness of the walls which is a matter of strength rather than of porosity.

Jointlessness is the especial quality of monolithic construction, and the art or science of concrete design and erection is now equal to the task of making at least such a simple structure as a stand-pipe quite monolithic and so uniformly dense that there will be no void spaces, or none near the surface. Such a structure should not show efflorescence.

But even if there is still the possibility of the occurrence of two or three white spots the showing surface of concrete work ought to be finished with some regard for appearances. We know now how to obtain a really handsome and satisfactory surface finish, pleasing in texture and tone and free from "crazing," and no work—especially no public work—should be made to exhibit so unlovely a face as the ordinary cement surface produces, and with its knowledge of the present state of the art the Engineering News should not throw up its hands in this style and discourage good taste in construction.

Very respectfully yours,

Henry H Quimby.

3920 Girard Ave., Philadelphia, Aug. 20, 1900.

[It is true that many of the efflorescent spots on the Attleboro stand-pipe are along lines which indicate "imperfectly adhering joints," but by far the heaviest efflorescence is in the area just above the curbing, where it is evenly distributed and not confined to one line or spot. The even distribution of this saline deposit and the absence of any water or even moisture on the surface shows that the concrete mixture in this area is of uniform density sufficient to prevent direct leakage but insufficient to stop a porous percolation with consequent leaching out of the salts. The problem before the constructor of concrete resisting water pressure then is not only to avoid lines of weakness but to procure a uniform density of such compactness that even this infinitesimal porosity cannot exist. The former is easy enough, but the latter is an extremely difficult matter when pressures of 40 or 50 lbs. per sq. in. are concerned.—Ed.]

Fine Grinding in Cement as an Indication of Strength.

Sir: Referring to the letter on "Fine Grinding of Cement," in your issue of Aug. 12, 1900, p. 179, and also to your note in July 22, 1900, p. 105, I would call attention to the tests on fineness and strength on all the different brands of cement used on public work in the city of Philadelphia, from 1901 to 1907, inclusive, as published in the annual reports of George S. Webster, Chief Engineer, City of Philadelphia.

These tests show that the fineness, since 1904, on all the brands averaged over 92% on No. 100 sieve, and except in a few instances, over 75% on a No. 200 sieve, as required by the standard specifications, American Society for Testing Materials, yet they do not show that the finest ground cement was the strongest. While there may be little question but that fine ground cement will show greater strength than coarse ground cement, provided clinker is identical, the fact that soft burnt (clinker) cement grinds easier than hard burnt (clinker) cement, makes it very easy for a manufacturer to make a showing in fineness, without necessarily getting a corresponding increase in strength.

The tests prove that the strength of cement does not go hand in hand with the fineness. This being the case, it would seem to indicate that in buying cement, the fineness is not an essential matter, but that the strength of the cement, when mixed with three parts sand, its permanency and constancy of volume, as shown by the accelerated tests, specified by the American Society for Testing Materials are the important factors for an engineer to take into consideration.

Very truly yours,

Wm. G. Hartranft,
Assoc. Am. Soc. C. E.

Real Estate Trust Building, Philadelphia, Pa., Aug. 16, 1900.

[These tests show results on 18 different brands of cements, nine of which were used throughout the whole seven years. The following table gives the general average for the seven years for those nine brands:

Brand.	Percentage through sieve. No. 100, %	Percentage through sieve. No. 200, %	Tensile strength sand test 1 to 3. 7 days. Lbs. per sq. in.	Tensile strength sand test 1 to 3. 28 days. Lbs. per sq. in.
A	93.2	76.4	257	333
B	93.3	77.2	208	287
C	92.6	76.5	245	336
D	92.8	76.3	223	322
E	95.3	78.3	284	373
F	94.8	76.7	204	290
G	92.4	75.0	243	316
H	91.9	75.7	258	329
I	92.7	74.4	240	329

The remainder of the table is too extensive to republish here, but it bears out Mr. Hartranft's statement.—Ed.]

Annual Convention of the American Boiler Manufacturers' Association.

The 21st annual convention of the American Boiler Manufacturers' Association was held at the Hotel Ponchartrain, Detroit, Mich., on Aug. 10, 11 and 12.

Mr. J. C. McCabe, Chief Boiler Inspector, Detroit, addressed the convention, stating that at the present time there are before the city council of Detroit two widely different proposed ordinances covering boiler inspection. He has recommended, for adoption, rules patterned after those of the Massachusetts Board of Boiler Rules. At the last meeting of the Michigan legislature, there being no state inspection law, a bill was passed providing for inspection of all boilers on inland lakes, but no legislation now exists in this state covering land boilers. It is thought that the ordinance passed by the city of Detroit may serve as a model for subsequent state legislation.

There are in the state of Michigan, according to Mr. McCabe, some 9,000 steam boilers, many of which are of antiquated type, and there have been many disastrous explosions, the record of the state being perhaps the worst of any in the Union. He instanced the "Journal" office explosion, 1895, with 32 lives lost; the Pemberthy Injector Co., 1900, 33 deaths; a blow-up in Metropole Hotel, with three lives lost, and an explosion at Dowagiac, Mich., three months ago, with three killed. The records show that less than one-half of the boilers in the state are inspected at all. It is expected, however, that shortly there will be appointed by the Governor of Michigan a commission to report on the advisability of state inspection laws.

The question why heavier boiler-heads are required for service on Western rivers than on the Atlantic coast was discussed by Mr. T. M. Rees (Pittsburg, Pa.) and Col. E. D. Meier (New York City). The latter called attention to the hard service of boilers on Western rivers, resulting from high steam pressures and heavy forcing (as much as 50 lbs. coal per sq. ft. of grate per hr. are often burned). Mr. Rees mentioned that the Government rules now require ⅝-in. heads for 40-in. boilers on Western rivers. The ½-in. heads formerly used needed patching frequently. Most of these boilers are externally fired and have from two to seven flues, the latter number giving the better arrangement in his opinion.

The best method of maintaining circulation in corrugated-furnace boilers was the next subject for discussion. Various devices to promote circulation were suggested, including steam jets in the boiler and baffle-plates in the furnace. It was stated that the chief trouble from poor circulation was likely to occur while raising steam. Col. E. D. Meier recalled that, although navy orders required that in Scotch boilers steam should not be raised in less than six hours, at the battle of Santiago it had been done in three hours without harm to the boilers. Firebrick baffle-plates to deflect the gases downward against the bottom of the furnace flue were commended by Mr. F. B. Slocum (Brooklyn, N. Y.); he said they not only distributed the hot gases favorably, but also helped by keeping down excessive ash deposits and thus keeping up the heat transmissibility of the furnace bottom. Mr. Rees, however, reported trouble in finding a suitable material for the baffles.

One member having mentioned bad results in heating rivets by oil furnace, where scale formed

on the rivets and leaky joints resulted, there was quite a bit of discussion on oil furnaces. In the case cited it had been found that excessive air pressure was responsible, and that uniformly good results were obtained when the air blast was cut down to 8 or 10 lbs. per sq. in. Other members also reported trouble with rivets heated in oil furnaces, due to scale, but it appeared that insufficient skill in using the furnace was generally responsible.

The question was raised whether the extending use of electric power, of gas and gasoline engines, and of water-powers, had reduced the demand for steam boilers. The opinion seemed to be that fewer small steam engines and boilers are sold than before the general introduction of central electric power and of gas engines. Many small manufacturing plants are now buying electric power; portable machines of many kinds, as road rollers, concrete mixers, etc., which formerly depended on steam power, now are fitted with gasoline engines.

REPORT OF COMMITTEE ON UNIFORM SPECIFICATIONS.—This report discussed and made recommendations concerning the specifications as to sulphur and phosphorus in boiler-plate and concerning the substitution of the elastic limit for the ultimate strength as a basis for calculating allowable working pressures.

An agreement had been made in 1905 with the American Association of Steel Manufacturers whereby a compromise was effected on the maximum allowable per cent. of phosphorus and sulphur in boiler-plate, raising the amounts fixed by the 1889 specifications of the American Boiler Makers' Association which were drawn up originally in 1889. The report stated that the steel plate manufacturers had fulfilled this agreement only when the American Boiler Manufacturers' Association was directly concerned and had maintained the standard specifications of the American Association of Steel Manufacturers as the basis for the general trade. It was therefore recommended to readopt the original specifications of 1889 as to sulphur and phosphorus.

A resolution to that effect was adopted by the association. The 1889 specification for boiler-plate both basic and acid, specifies maxima of .04% phosphorus and .03% sulphur.

In regard to the substitution of elastic limit for ultimate strength in computations of shell thickness, the committee gave reasons against such a change, the principal ones being the difficulty of determining the elastic limit or yield-point and the confusion which might result from attempting to change the present practice.

ELECTION OF OFFICERS.—Officers for the coming year were elected as follows: President, E. D. Meier, New York City; Secretary, J. D. Farasey, Cleveland, Ohio; Treasurer, J. F. Wangler, St. Louis, Mo.; Vice-Presidents, J. Don Smith, W. A. Brunner, H. D. Mackinnon and M. A. Ryan. It was decided to hold the 1910 convention at Chicago, Ill., and a motion was carried that, as an experiment, the 1910 convention be extended to four days, beginning on a Monday instead of on Tuesday as heretofore.

A Dividing Scale for Charging for Public Utilities.

By W. D. MARKS,* M. Am. Inst. E. E.

A logical and equitable division of increased profits, over and above agreed standards, in the conduct of a public utilities business has long been desired but only distantly approached. The most notable attempt has been in what is known as the London sliding-scales, for gas. It is obviously fair, if the cost of supplying an utility has been reduced by good business management or by fine engineering skill, that half the reduction should go to the company in the shape of increased profits and half to the patrons supplied, in the shape of a reduction in the price of service. Until the writer formulated the method of division discussed later, no established general theory of a dividing scale had been stated. The famous London sliding scale is only an arbitrary division of extra profits between company and consumer by means of an increased dividend on stock for each penny of reduction in the price of gas, each time the price was lowered. For a 10% stock this is commonly an increase in dividend of ¼ or ⅓ of 1%. The result has been to give nearly all the benefit to the consumer after the first few reductions and after the charging price became much below the standard price. In extreme cases, it is said, the consumers receive seven-eighths the benefit of the reduction and the company is rewarded with only an eighth for its ability to reduce the price.

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The writer has deduced a logical solution of the problem and it is here presented. The following quantities must be determined for the chosen current year of operation of the company in mind.

(1) The unit of quantity of product and its standard selling price.

(2) The standard dividend earned by capital invested.

(3) The capital invested per unit of quantity of product produced.

(4) The cost of supplying a customer with the unit of quantity of product.

These quantities appear in the following notation, which is stated preliminary to developing a dividing-scale formula.

p = standard price of unit quantity of product.
a = standard dividend on that stock whose dividend is not fixed, known as "dividing-scale stock."
m = amount of the dividing-scale stock per unit of quantity of product produced per year.
c = cost of producing a unit of quantity of product, including interest on bonds, preferred dividends, fixed charges, etc.
r = reduction in unit price of product.
x = unit increase in dividend, for each unit reduction, "r."

It is obvious, of course, that for each numerical case the values ascertained for each of the above quantities must be reduced to a comparable basis. On condition of equal division of extra profit above the standard dividend we have the equation

$$p - r - c = m\,(a + r\,x) = \text{total profit} \ldots\ldots (1)$$

A study of the physical interpretation of this equation shows that the standard price less the cost equals the standard dividend times the capital per unit quantity of product, and that the reduction in price per unit quantity of product equals the capital, per unit quantity, times the increase in dividend. Expressed mathematically,

$$m\,r\,x = r$$

and

$$x = \frac{1}{m} \qquad (2)$$

This equation (2) is the key to the whole idea of equitable division of extra profits. It means that the increase in dividend for unit reduction in price should be the reciprocal of the investment, per unit quantity of product. Placing this value of "x" in Equation (1), we have,

$$r = \frac{p - m\,a - c}{2} \qquad (3)$$

The same result here deduced might be inferred by considering that half the reduction of unit cost goes to the consumer as a reduction in price. But $(p - m\,a)$ in Equation (3) is only one statement of the original standard cost of unit quantity of product. Thus Equation (3) seems logical from any point of view.

Applying this sliding scale to the case of eight gas companies in Massachusetts, selling gas by the usual standard unit of quantity, M. cu. ft., we find that,

p = 90 cts.
c = 60 cts.
a = 0.11 ct.
m = 182 cts.

Inserting these in Equation (3):

$$r = \frac{90 - 182 \times 0.11 - 60}{2}$$

$$= 4.99 \text{ cts. reduction per M cu. ft.}$$

$$x = \frac{1}{152} = 0.0055$$

For the increased dividend we have:

$$a + r\,x = 0.11 + (4.90 \times 0.0055)$$
$$= 0.1375$$

which is equivalent to the more commonly used term "dividend of 13¾%."

Applying this dividing scale to street railways and taking results of the recent thorough investigation of the system in Cleveland, Ohio, we have:

Unit quantity of product = one passenger fare.

m = 18 cts.
c = 3 cts.
p = 4 cts.
a = 0.05 ct., from which;
r = 0.05 ct.
x = 0.555 ct. for each 0.05 ct. reduction of fare.

What may be termed in this case "permissible profit" is .05 × 18 = 0.9 ct. per passenger fare. The actual is 1.0 ct., but as in this case reduction can hardly come in smaller units than 1 ct. no reduction to a 3-ct. fare is safe. Such a low fare is possible by an increase of traffic or added economy so that "m" or "c," or both, are reduced. An inspection of Equation (3) for this case shows the surprising result that even if the investment per passenger fare were reduced to approximately zero a fare reduction of only ½-ct. would be equitable. With the same investment per passenger fare a cost "c" of 1.1 cts. would be necessary. But it is probable that an increase of traffic would reduce both the "m" and "c." For a reduction of fare of 1 ct. to be safe, from Equation (3)

$$1 = \frac{4 - (0.05\,m + c)}{2}$$

$$(0.05\,m + c) = 2$$

This would be satisfied when new values of "c" and "m" had been established of say 1.8 and 4 cts. respectively, or 1.9 and 2 cts, or 1.99 and 0.2 ct.

This dividing scale is equally applicable to the adjustment of rates and dividends in the case of steam railways. That part of the Chicago, Milwaukee & St. Paul R. R., in Wisconsin in 1905, will be considered. In this example only the simpler quantities are taken, to exhibit the method, although the intricate forms of capitalization can be dealt with if necessary. The unit of quantity taken is the train-mile. This is selected and used solely because it is given in Wisconsin reports. If the train-mile is used for more than one year, it should be standardized and its relation to passenger-miles, ton-miles and car-miles should be fixed definitely. By this means it would be possible to fix passenger and freight rates for various services and forms of merchandising, simplifying the enormous detail and confusion of present schedules.

The train-miles for 1905, both freight and passenger, were 7,657,137 (Rep. Wis. R. R. Com., 1905, p. 664). The value of the railway in the state, complete, was $60,469,562 (p. 486). The total earnings in the state for the year were $15,681,878 (p. 486). The operating expenses and taxes for the period were $10,173,220 (p. 506). On this basis we may state:

$$p = \frac{15,681,878.00}{7,657,137} = 205 \text{ cts.}$$

$$a = .08$$

$$m = \frac{60,469,563}{7,657,137} = 789 \text{ cts.}$$

$$c = \frac{1,017,322,000}{7,657,137} = 133 \text{ cts.}$$

It will be noted that the receipts per train-mile were 205 cts. instead of the standard 199 cts. (133 + .08 × 789), so that a reduction is equitable. Substituting in Equation (3):

$$r = \frac{205 - 789 \times .08 - 133}{2} = 53.0 \text{ cts.}$$

$$x = \frac{1}{789} = 0.00127$$

$$a + r\,x = 0.08 + 0.067 = 0.147$$

This is a 14.7% dividend, commonly speaking. If, in an ensuing year, we can, by economy and increased traffic, reduce "c" to 100 and "m" to 500 we have

$$r = \frac{152 - 100 - 40}{2} = 11 \text{ cts.}$$

$$x = \frac{1}{500} = 0.002$$

$$a + r\,x = \text{dividend} = 0.147 + 0.022 = 0.169$$

This is a 16.9% dividend, commonly speaking.

This formula and method is applicable for any business of selling water, gas, electricity, train-miles, passenger fares, etc., for it includes all the factors naturally and legitimately affecting the finances of any such business. It should clear up the situation for those seeking a basis for selling this service. The figures used above have been fixed only approximately, and to show only the application of the scale. The quantities involved must be determined by careful research of men of requisite training and experience.

Prices unchangeably fixed have always been failures from the viewpoint of either consumer or manufacturer, or perhaps of both. This scale allows an alteration of price which offers in an increased dividend a strong inducement for price reduction. This is a reward for increased skill in economy of production. It provides the possibility of raising prices above standard, with a decrease of dividend, and enables a concern to share with its customers, a loss due to scarcity of raw material, increase in cost of productive labor, or a falling off in sales because of stringency. In the case of the gas companies first taken up suppose these conditions had combined so that two new values of "c" and "m" were found:

$$c = 75 \text{ cts.}$$

$$m = 190 \text{ cts.}$$

Then

$$r = \frac{90 - 190 \times 0{,}11 - 75}{2} = -2.5 \text{ cts.}$$

The negative value of "r" indicates permissible increase in price to 92.5 cts. There would be a corresponding decrease of dividend according to the following:

$$x = \frac{1}{190} = 0.00526$$

$$a + r\,x = 0.11 - (2.5 \times 0.00526)$$

$$= .097$$

This means a dividend of 9.7% instead of 11%.

An agreement to use this dividing-scale, being a contract for a number of years, protects the corporation from interference and other revision of prices. The scale is equitable in its practical operation whether the corporation requires a large investment to do a small business or the reverse. Use of such a dividing scale with publicity will prevent stock dilution and the resulting forms of corporate extortion and will help to place the securities of public-utility concerns on a better investing basis.

Further Bacterial Studies of the Effect of Storage of London Water.

The London water-storage studies made by Dr. A. C. Houston, Director of Water Examination, Metropolitan Water Board, have been abstracted and commented upon from time to time in these columns. In the third annual report of the Board, covering the year ended March 31, 1909, Dr. Houston gives the following conclusion regarding tests to determine the safe period of water storage to guard against bacterial infection:

It is now possible to judge by comparatively simple tests and with reasonable accuracy, whether *raw* river water has been stored for a length of time, sufficing to ensure destruction of all (or nearly all) typhoid bacilli (and inferentially also of other microbes, causing water-borne disease) if these happened to be present originally in the water. This distinctive and valuable knowledge is arrived at, by correlating the results of tests dealing with the longevity of the typhoid bacillus in raw river water, with those showing the length of time that raw river water must be stored before it exhibits certain changes in its original composition. Hence a new factor has arisen in the work of examining the London waters, which is believed to be of primary importance. Briefly, dependence is now being placed more and more on experimental proof that the water reaching the filter beds, as the result of adequate storage, is in a reasonably "safe" condition *antecedent* to filtration.

In his fourth Research Report, just published, Dr. Houston gives conclusions based on the results of studies of the vitality of the cholera vibrio bacillus in artifically infected samples of "raw" or untreated water from the Thames, Lee and New rivers, these studies also having been made "with special reference to the question of storage." We quote as follows:

Subject to certain qualifications set forth elsewhere in the report, which need not be repeated here, the following broad conclusions may, I think, safely be drawn from the results of the investigation.

(1) Cholera vibrios die very rapidly in *raw* Thames, Lee and New River water as the result of storage in the laboratory. At least 99.9% perished within one week, and in none of the experiments could any cholera vibrios (recognizable as such) be found even in 100 c.c. of water three weeks after its infection. In more than half the experiments the results were negative by the second week.

(2) The isolation of cholera vibrios from *artificially* infected *raw* river water presents no insuperable difficulties even when the number artifically added is very small, both actually and relatively to the bacteria normally present in the river water.

(3) On the other hand, microbes liable (after careful study) to be mistaken for true cholera vibrios were not found in comparable, but non-infected, river water samples examined under precisely similar conditions.

(4) All that I have said in the past as regards the advantages of storing river water from the point of view of typhoid fever applies also to cholera, and the time required to ensure reasonable safety in the former case, is, on the basis of these experiments, more than sufficent in the latter.

(5) There are many circumstances which separately, and still more in conjunction, tend to safeguard this country from a cholera invasion. But no responsible authority can regard a cholera visitation as impossible, and, if it is possible, the part played by impure water in the past in spreading the disease should not be forgotten. Fortunately, even an initially impure water can, by adequate storage and efficient filtration, be brought into a condition of reasonable, if not absolute, safety.

(6) In the particular case of the Metropolitan Water-Supply, there remain four reassuring circumstances even in the extreme (and, it is to be hoped, highly improbable) event of the raw sources of water-supply ever becoming infected with cholera. Firstly, the cholera vibrios even if they were present in very few numbers could be detected in the river water by appropriate tests. Secondly, adequate storage of the river water would eliminate the great majority, if not all, of them. Thirdly, the final filtration process, if efficient, would be an additional safeguard of proved value. Lastly, as the result of my experience at Lincoln I should not be unprepared *in any emergency* to face the responsibility of sterilizing the water-supply, if this was thought to be desirable, and so rendering it absolutely safe for drinking purposes. The existence of large storage reservoirs renders such a project quite feasible as a temporary expedient.

(7) Although by no means defending the choice of an impure river water for water-works purposes, the facts revealed in this report appear none the less to be of a reassuring character, and to form another link in the chain of evidence which I have sought to establish, namely, that by adequately storing the *raw* impure river waters which constitute the chief sources of London's water-supply, antecedent to their filtration, the safety of the metropolis as regards water-borne epidemic disease (apart from the possibility of accidental infection at the works, or subsequently in the pipes) is almost, if not quite, assured.

Column Strength in Relation to Length-Ratio, End Conditions, and Elastic Limit of Material; Watertown Arsenal Tests.

Extensive experiments on the strength of steel columns, which have been in progress at Watertown Arsenal, Mass., for the past two years, are beginning to yield interesting results. Three diagrams summarizing a considerable number of careful comparative tests were shown by Mr. J. E. Howard of the Arsenal testing laboratory at the recent annual meeting of the American Society for Testing Materials. As these diagrams give an instructive representation of column strength, we reproduce them herewith as Figs. 2 to 4, together with a picture of an unusual test column which was added to the series (Fig. 1).

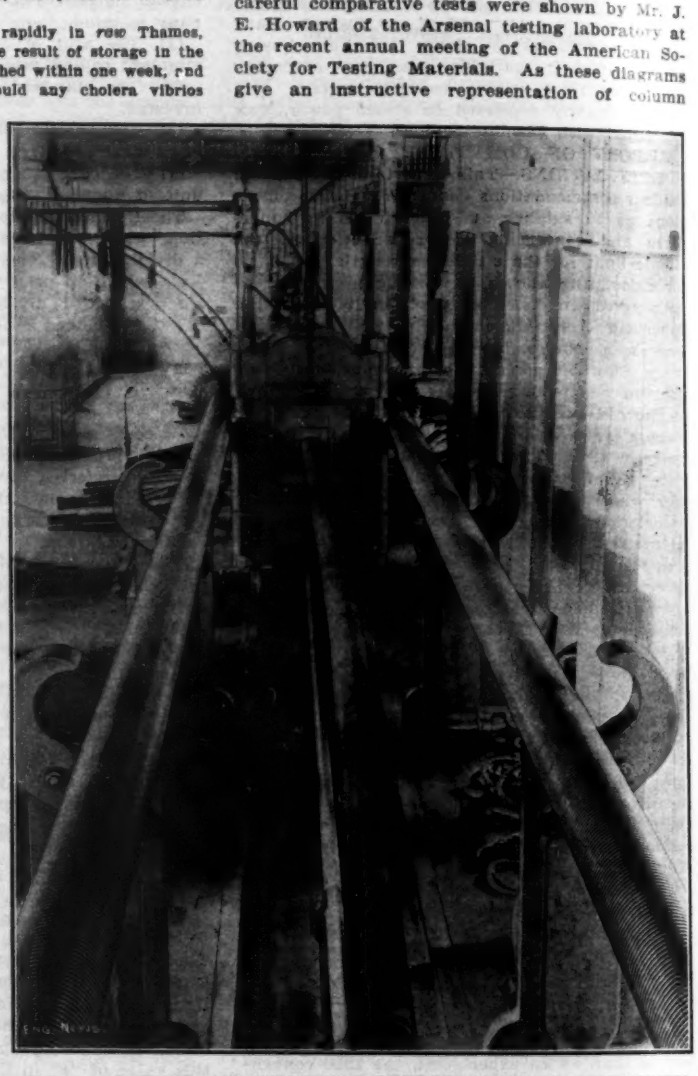

FIG. 1. A TUBE COLUMN WITH BUTTED JOINT AT MIDLENGTH; VIEW AFTER MAXIMUM LOAD.

(The total length of this strut was 150 r. It was cut across at the middle and the two parts merely butted. In this condition it had a maximum strength of over 29,000 lbs. per sq. in. with little deflection; during its subsequent deflection it showed a strength of 19,500 lbs. per sq. in.)

The lines of the diagrams are averaged for three or more tests of the same kind. Four end-conditions are represented in Fig. 2. It will be seen that their lines might without great error be called coincident. Figs. 3 and 4 have lines for only two end-conditions, viz., flat and pin, and here also the lines coincide closely, up to lengths of between 125 and 150 r. In Figs. 3 and 4, also, are marked the individual test results, from which it appears that tests of the same kind duplicated each other very satisfactorily.

The shaded areas in all three diagrams denote the range of the elastic limit of the steel composing the columns. That this zone has much to do with fixing the ultimate strengths of the columns is quite apparent.

Roughly, we may conclude that for length-ratio between 50 and 125 the strength of these col-

umns was equal to the elastic limit of the metal, ranging close about 30,000 lbs. per sq. in.

For lengths shorter than $l = 50\ r$, the columns do not fail until a higher load is applied, though probably their compression curves would show an elastic limit of column lying either at or below the elastic limit of the steel. On the other hand, columns longer than $l = 125\ r$ seem to possess lower strength, the curve falling away with increasing length-ratio about as might be expected from Euler's law of buckling strength.

SPECIAL TESTS.—The effect of transverse loads upon the strength of a column was tried in two instances. Using a center load great enough to produce an extreme-fiber stress of 15,000 lbs. per sq. in., one column showed a failure strength in compression of 23,480 lbs. per sq. in., while the other could carry a maximum load of only 9,172 lbs. per sq. in. In the former, the deflection due to the transverse load decreased under the initial compression loads, showing that the existing eccentricities were in such direction as to tend to counteract the transverse load. The second column, after being buckled to a deflection of over 3 ins., was removed and straightened, and on retesting showed an ultimate strength of 26,000 lbs. per sq. in. This indicates that, though the two columns differed in length and in condition of ends, these factors were of minor influence only.

Another column was tested with an unconnected butt-joint at mid-length, the column (flat-end, $l = 150\ r$) being cut in two and the two halves simply butted in the testing machine. Its maximum load was 29,280 lbs. per sq. in. At the time it was photographed (Fig. 1) it had attained a deflection of about 3 ins., and its load then was 19,500 lbs. per sq. in.

BUILT COLUMNS OF SHORT LENGTH.—Mr. Howard in his paper calls special attention to the fact that while the strength curves of solid-metal columns (Figs. 2 and 3) slope upward sharply below the value $l = 50\ r$, the curve for the built columns (Fig. 4) shows practically no change here.

The shortest columns of the built members did not show that gain in strength which was displayed by the solid rolled or annular sections. The plates and angles of these short columns appeared to act independently rather than as a unit.

This finding is of great importance. The built columns were designed to first-class modern practice, so that it is not easy to claim that poor detailing is responsible for the effect noted. We will be safe in concluding that ordinary structural-steel built columns of all lengths up to 100 r fail practically at the elastic limit of the metal which composes them.

Memoranda on Dredging in Ambrose Channel, New York Harbor.*

By H. L. WIGMORE.†

The River and Harbor Act of 1899 adopted a project for making an entrance to New York by way of Ambrose Channel, formerly known as East Channel. This project provided that the new channel, 7 miles long, should be 2,000 ft. wide and carry a mean low-water depth of 40 ft. The excavation required was estimated at 42,500,000 cu. yds., and the act limited the cost of this work to $4,000,000. It was originally intended that the entire work would be performed by contract, and a bid of 9 cts. per cu. yd. was accordingly accepted. Progress was so slow, however, under the contract, that in 1903 two dredges were built by the United States to supplement the contract work. In October, 1906, the contractor abandoned work entirely, and since then it has been carried on by the United States alone. The River and Harbor Act of 1907, increased the limit of cost of the work to $5,148,514, and, under authority of this act, two more dredges were constructed.

At the present time a width of 1,000 ft., carrying 40 ft. of water the entire length of the channel, is practically completed, 35,000,000 cu. yds. of material having been removed to bring the project to this stage. It has been found that, due to over-depth in dredging, which averages 2½ ft., the original estimate should be increased by about 7,000,000 cu. yds., independent of the filling that may be going on.

The plant now in operation consists of four sea-going suction dredges, (1) The "Manhattan," in operation since Nov. 15, 1904; (2) the "Atlantic," since April 28, 1905; (3) the "Raritan," and (4) the "Navesink," both in full operation since July 1, 1908. The "Manhattan" and "Atlantic" are boats of 2,670 tons, 288 ft. long and 47½-ft. beam, with a draft, light, of 10.5 ft. and loaded of 22 ft. The "Raritan" and "Navesink" are of 2,930 tons, gross; 290 ft. long, 47½-ft. beam, with a draft, light, of 14.3 ft., and loaded, 24 ft.

Their general appearance is that of the usual steel-hull freighters, except for the suction tubes, which project from each side about one-third the length from the stern. Inside, however, they consist principally of two large bins, of steel boiler plate, extending in depth from the upper deck to the bottom of the ship, and each in length about one-sixth of the ship's length. The forward bin occupies the after part of the forward third of the ship and the after bin the forward part of the after third.

The lower 5 ft. is divided into eight inverted truncated pyramidal sections, each fitted at the bottom with a horizontal gate in each section, swinging on horizontal fore and aft hinges. These gates are 3 ft. 6 ins. by 4 ft. 4 ins., and while not absolutely water-tight are practically so. They are opened by vertical wrought-iron rods carried up to I-beams running across the top of the bins and operated by power through a worm-and-toothed gear or by large hand wheels. About 3 ft. from the gate the rod has an eye-bolt splice, which permits the rods to maintain their verticality while the gates are swinging. The bins are built in the ship quite independently from the hull and are heavily braced along the sides and bottom by I-beam struts extending from the exterior of the bin to the hull. Stiffening pieces were also placed across the ends in the newer boats, but these are believed to be quite unnecessary.

Fore and aft tie rods connect the two ends of each bin in the older boats, but these have been found to be not only unnecessary but a positive evil, as the constant fall of mud tends to bend them and so pull them out of their fastenings or buckle the end plates of the bins.

The forward bins in the old boats have a capacity of 1,270 cu. yds., and after bins 1,200 cu. yds. Their usual load is, however, only about 2,000 cu. yds. In the new boats the forward bins have a capacity of 1,527 cu. yds. and the after bins 1,391 cu. yds. In good weather they usually carry about 2,700 cu. yds., reducing to 2,500 in a rough sea. The vessels are all twin screw with an ordinary speed of 10 knots. Their engines are compound, each of 850 HP., but can produce about 930.

The pumping apparatus consists of two centrifugal pumps, 8½ ft. in diameter, placed in the engine-room compartment, midway between the main deck and the floor of the engine room, on each side of the ship. These are operated independently, each by a compound marine engine of 465 HP. at 155 r. p. m. In the old boats, where the pump vanes are worn, as high as 205 r. p. m. are made. The consumption of coal for all purposes is about 40 tons per day of 24 hours. One condenser in the new boats serves all engines, while the old ones have one condenser for the propeller engines and one for the pump engines. Each pump is direct connected by a shaft to its own engine, and from its exterior the suction pipe leads through the hull to the outside of the ship, where an elbow attached by a movable joint permits the rest of the suction pipe, extended aft longitudinally along the hull of the ship, to have a vertical motion. Below this elbow is a ball-and-socket joint, which gives play to this same part when in operation. At the end of the suction pipe is what is known as a drag, which is an improved and far more efficient form of the old bell-shaped mouthpiece. It is in general appearance a flattened extension of the suction pipe with the lower half cut off and a heavy iron grating having about 6-in. openings substituted

*From a paper in "Professional Memoirs" Engineer Bureau, U. S. Army. Jan.-Mar., 1909.

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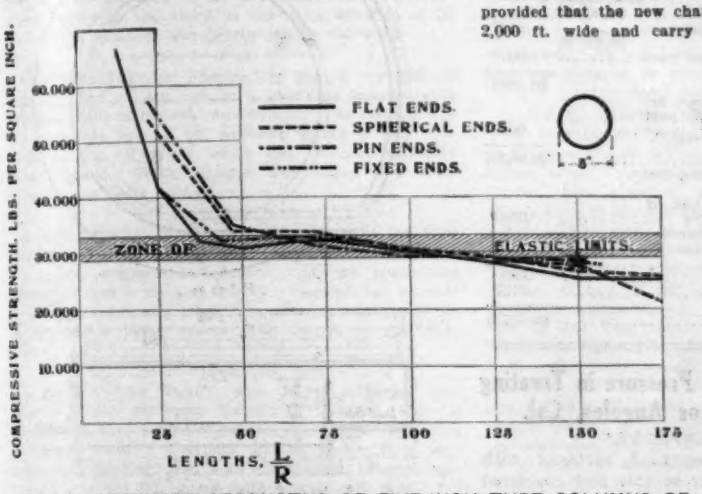


FIG. 2. ULTIMATE STRENGTHS OF FIVE-INCH TUBE COLUMNS OF VARIOUS LENGTHS.
(The star denotes the failure strength of the jointed column shown in Fig. 4.)

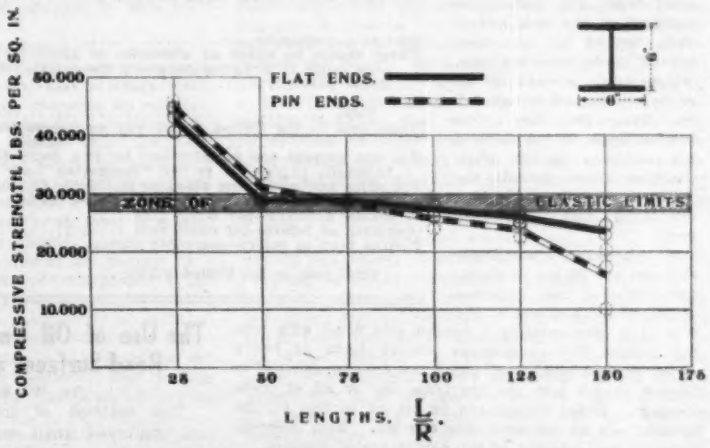


FIG. 3. ULTIMATE STRENGTHS OF ROLLED 6-IN. H-SECTION COLUMNS OF VARIOUS LENGTHS.

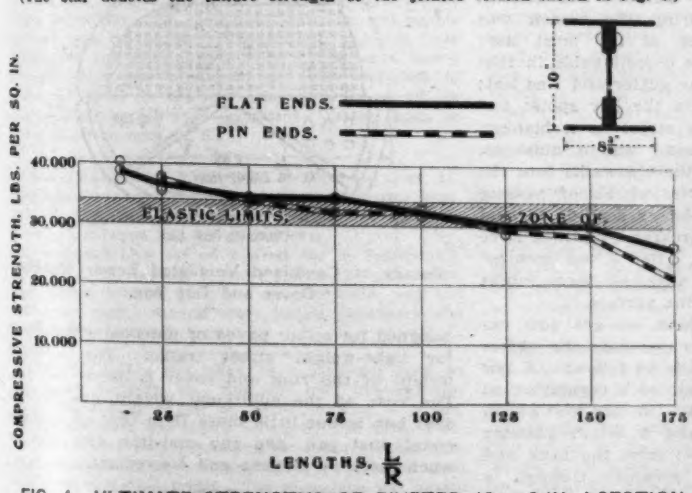


FIG. 4. ULTIMATE STRENGTHS OF RIVETED 10 x 8-IN. I-SECTION COLUMNS OF VARIOUS LENGTHS.

FIGS. 2-4. RESULTS OF COMPRESSION TESTS OF THREE TYPES OF STEEL COLUMN, AT WATERTOWN ARSENAL, MASS.

therefor. The suction pipes are raised and lowered by wire falls hung from special davits located on the upper deck over the end of the suction pipes. The falls are operated by two horizontal engines with 8-in. by 10-in. cylinders, connected to the drums and controlled through levers from a small bridge by the davits. The pumps are of the usual vane type of centrifugal pump with some changes found to give greater durability. These consist of the substitution of steel castings in the shell for cast iron, as it was found that cast iron could not withstand the impact of stones brought up through the pipes.

Steel lining for the vanes was also found impractical, as the first notice of any wear there was generally a piece of the lining coming out through the shell.

In the new vessels there are five vanes in each pump, as compared with four in the older type. The material is received at the axis and is then carried by the vanes around to the receiving tube, which leads upward at an angle of 90° and branches 2 ft. from the fan. One branch leads to the forward bin and one to the after. Overflow pipes permit the water to run off till the bins are filled with solid material.

All pipes are interchangeable and are 20 ins. in diameter. Where the branches reach the top and end of the bins, they open through a wooden gate fitted with rubber gaskets into rectangular sluices made of heavy wrought-iron plates, from which the dredged material is allowed to fall into the bin from any or all of these openings. Either branch can be cut off so that all the material can be delivered into one bin. With different materials the capacity of the pumps varies slightly.

The average capacity of the new pumps, at about 35 ft. depth and dredging fine, hard-packed sand, is 13 cu. yds. per min. or 6½ cu. yds. per pump running at 155 r. p. m. In loose sand and fine gravel the average is about 20 cu. yds. per minute; in soft mud, about 9. This, it should be noted, is solid material as carried to the dumps, not the actual capacity of the pumps, which averages 172 cu. yds. of liquid matter per minute or 86 cu. yds. per pump. In operation, the average time for filling the bins may be taken as 3 hrs. 10 min. From the operating ground to the dumping ground and back will generally, on the average, considering work over the full length of the channel, take 2 hrs. 30 min., which includes ten minutes for dumping. About five minutes is lost each time the dredge has to turn while at work.

COSTS.—In calculations of the cost of operation of these dredges, only those items that would be considered in a contractor's figures should be used; as the item for consideration is, whether the work could be done cheaper by contract. Therefore, cost of surveys and examinations should not be considered but, conversely, interest, insurance and sinking fund should be.

In estimating the cost of the completed work to the government, all the above, however, except interest and insurance, should be included.

The record of the operation of the "Manhattan" and "Atlantic" for the complete year ending June, 1908, being on file, is shown for the operation of the "Manhattan" in the accompanying table.

The "Manhattan" and "Atlantic," now three years in operation, are, so far as condition is concerned, as good as when new. Their efficiency is much greater than when first placed in operation.

In the case of the "Raritan" the records for the first three months of her operation show a total cost of operation of $22,285.46. She removed in this time 641,513 cu. yds., giving a cost per yard of 3.58 cts.

The other items for arriving at the total cost to the United States, not at present obtainable, would be approximately the same as for the "Manhattan," making the total cost to the United States of $0.05403 per cu. yd.

The work has been in charge of Gen. W. L. Marshall up to now, assisted by Lt.-Col. S. W. Roessler, Mr. H. N. Babcock, Assistant Engineer, and Mr. H. L. Potter, Junior Engineer

TABLE SHOWING OPERATING RECORDS OF DREDGE "MANHATTAN" FOR 1908. AMBROSE CHANNEL, NEW YORK HARBOR.

1907-8.	*Pay roll.	Coal.	Subsistence.	Supplies.	General repairs.	Wharfage.	Totals.
July	$2,994.33	$2,743.30	$729.18	$175.95	$5,725.33	$62.50	$10,430.59
August	2,646.83	3 335 06	879.29	458 05		62.50	7,581.73
September	2,856.58	2,449.75	841.57	220.26	262.87	62.50	6,673.53
October	2,877.66	‡,460 38	838.38	164.05	344.88		6,693.35
November	2,919.67	3,048.40	931.92	673.58	895.07	125.00	8,593.64
December	3,015.25	2,536.85	731.31	450.86	69.84		6,804.11
January	2,898.83	2,434.54	811.04	242 57			6,386.98
February	2,806.33	3,464.53	919.65	594.56	235.23	187 50	8,207.80
March	2,862.16	2,692.04	780.73	622.22	9.89	62 50	7,029.54
April	2,898.50	2,510.82	758 57	446.54	864 74	62.50	7,541.67
May	3,129.66	2,317.48	967.16	363.90	710.78	62.50	7,551.43
		2,794.44					
June	2,705.83	2,024.47	801.71	292 30	119.18	90.09	8,827.93
Total	$34,791.63	$34,820.06	$9,990.46	$4,704.84	$7,237.81	$777.50	$92,322 30
	†2,400.00		†2,400.00		‡13,131.80		‡13,131.80
Total	$32,391.63	$34,820.06	$12,390.46	$4,704.84	$20,369.61	$777.50	$105,454.10
	‡1,500.00						‡1,500.00
Total	$31,891.63	$34,820.06	$12,390.46	$4,704 84	$20,369.61	$777.50	$103,954.10

*Pay roll. The full complement of the "Manhattan" is 58 men exclusive of the inspector.
†Cooks and waiters transferred to subsistence.
‡For repairs and supply of worn and broken parts, yearly account.
‡Inspector's salary would be paid by United States on contractor's plant.

The total yardage of the "Manhattan" for the period from June 30, 1907, to June 30, 1908, was 2,660,513 yds. Taking the total cost of operation as $103,954.10, which includes all items of expense which would be borne by a contractor, we have a cost per yard of	$0.039
Building cost of "Manhattan" was $340,041.58	
Ten per cent. sinking fund 34,004.16 = per yard	.0127
Insurance and interest taken at 7% 20,802.91 = per yard	.0078
Cost to a contractor	$0.0505
There should be added an allowance of 12½% in this case for over depth in dredging for which the contractor is not paid = per yard	.00557
Total	$0.06507
Total cost to the United States was as follows (excepting cost of vessel):	
For cost surveys and examinations for two boats $19,983.34 or $9,991.67, chargeable to the "Manhattan"—per cu. yd.	.0037
For office and contingent expenses $6,752.15, $3,376,075 for the "Manhattan." To this should be added $1,500 for the inspector's salary—per cubic yard	.00183
Operating as before—per cubic yard	.039
Sinking fund as before—per cubic yard	.0127
Total cost to the United States	$0.05723

The Use of Oil Under Pressure in Treating Road Surfaces at Los Angeles, Cal.

By W. M. HUMPHREY.*

The method of treating road surfaces with oil employed until recently in this city consisted of applying from ¾ to 1 gal. per sq. yd. of 70% asphalt oil, by a regular oil sprinkler without pressure, after which the surface was sanded. A second application during the season was found necessary on some of the most used streets. That method was objectionable in that some of the oil ran into the gutter and was lost; some of it formed pools in the low spots; and the rest remained on the street as a blanket, and until covered with sand was a nuisance, as it was tracked across the sidewalks into the houses and gathered on the wheels of passing vehicles. Even with this heavy coat of oil, and in fact on streets where greater quantities have been worked into the soil, after a few months' wear dust would appear, although there might be considerable oil under the surface.

By the method with which we are now experimenting we expect to overcome the objection to the old system. It is as follows: A low wagon is hooked to the rear of a regulation oil tank holding about 25 bbls. On this low wagon is a triple-action pump and a 5-HP. gasoline engine, which draws the oil from the tank and forces it under 35 lbs. pressure through a sprinkler at the rear. The sprinkler is a 2-in. pipe, 8 ft. long, with a row of 1/16-in. petcocks 4 ins. apart along the bottom. By this process a quart of oil to the square yard is forced into the loose surface. One man with the machine will discharge 200 bbls. per day. We believe three applications during the year will be necessary. By this process there is no loss of oil, and no sanding is required. In experimenting with different grades of oil we have found thus far that as a dust palliator 60% asphalt oil is preferable to 70% oil.

AROUND THE WORLD IN 41 DAYS and 8 hours is the record established by a party of schoolboys on Aug. 19. The trip was arranged by the Hearst newspapers of New York, Chicago and Los Angeles.

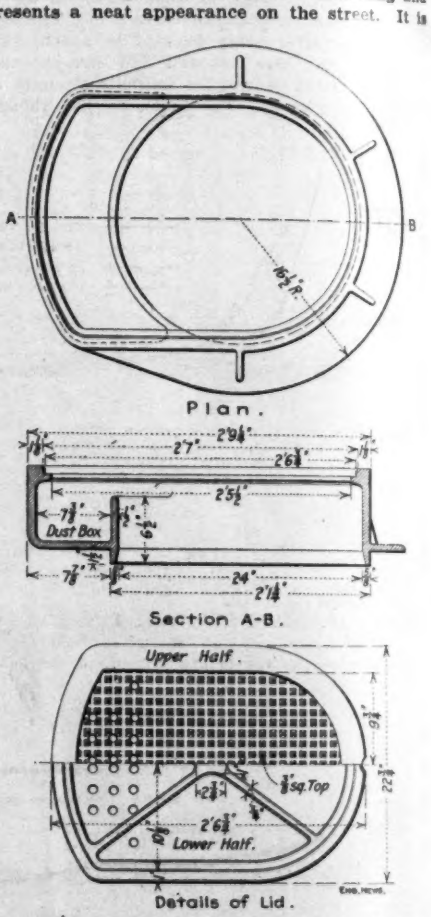
*Inspector of Public Works, Los Angeles, Cal.

A Combined Ventilated Sewer Manhole Cover and Dirt Box.

By WALTER G. KIRKPATRICK,* M. Am. Soc. C. E.

The accompanying illustrations show a manhole cover casting which I have been using satisfactorily for about ten years. It is designed for house sewers, with provision for ventilating the sewer, by air passing through holes in the cover, thence along through the sewer and through each untrapped house connection and outward through the main vent pipe terminating above the roof of the house. Provision is also made for collecting the dust from the street, falling through these holes into a dust box, which is a part of the manhole casting.

The advantages of this design are: the dust box is durable, easily cleaned, cannot drop itself nor its contents into the sewer, and allows easy access to the manhole and sewer for inspection; also the casting is immovable on its setting and presents a neat appearance on the street. It is



Details of Combined Ventilated Sewer Manhole Cover and Dirt Box.

designed for either paved or unpaved streets and for light-weight street traffic. The average weight of the ring and cover is about 425 lbs. The cost of the additional weight due to the dust box is but little more than that of a sheet metal dust pan, and the cast-iron dust box is much more permanent and convenient.

THE COMMON DRINKING CUP has been put under a ban by the Kansas State Board of Health (Dr. S. J. Crumbine, Secretary, Topeka) by the following regulation.

Whereas, It has been repeatedly demonstrated that the use of what is usually known as the common drinking-cup is dangerous and is an undoubted source of communication of infectious diseases; now, therefore, in the interest of the public health,

Be it ruled by the Kansas State Board of Health

That the use of the common drinking-cup on railroad-trains, in railroad stations, in the public and private schools and the state educational institutions of the state of Kansas is hereby prohibited, from and after Sept. 1, 1909.

No person or corporation in charge or control of any railroad-train, or station, or public or private school, or state educational institution, shall furnish any drinking-cup for public use, and no such person or corporation shall permit on said railroad-train, or station, or at said public or private school, or state educational institution, the common use of the drinking-cup.

*Jackson, Miss.

THE WIRELESS-TELEGRAPH STATION of the Marconi company at Glace Bay, Nova Scotia, where the transatlantic messages are sent and received, was partially destroyed by fire on Aug. 21. The operating and instrument rooms were gutted but the towers and operators' houses were saved. The damage to the buildings amounted to only some $8,000, but the loss in apparatus has not yet been fixed. The station and system will be out of use for several months until new equipment can be made and installed.

A POWDER MILL EXPLOSION Aug. 16 wrecked the dynamite house of the Western Explosives Co. at Turnstall Bay, Bowen Island, near Vancouver, B. C. Five men were killed.

A COAL BARGE BROKE AWAY FROM A TUG and sank Aug. 17 off Shinnecock, Long Island. Her crew of five men were drowned. The barge was one of six which were being towed by two tugs from Philadelphia, Pa., to Portsmouth, N. H. A heavy gale caused the six barges to break loose from the tugs and ten hours' work was required to pick up the five that remained afloat. The barges and tugs are the property of the Reading Coal Co.

A FISHING SCHOONER SANK Aug. 18 off the coast of Nova Scotia, 20 miles southwest of Sambro. Eleven men out of her crew of 17 were drowned. The survivors rowed to the shore in dories, a distance of 50 miles. The schooner was overturned by the wind.

AN EXPLOSION of illuminating gas is reported to have occurred on Aug. 23, in a purifying house at the city gas works of Geneva, Switzerland. The force of the explosion was terrific, all windows within a half mile being broken. The gas works and adjacent buildings were wrecked. Seven persons were killed and some sixteen were badly injured.

A BOILER EXPLODED on a locomotive of the Pere Marquette R. R., near Grand Ledge, Mich., Aug. 18, killing the engineer and fireman. A day coach was overturned and a sleeping car was derailed but no passengers were seriously hurt. The cause is ascribed to the failure of the boiler crown sheet caused by too little water.

A PREMATURE BLAST, Aug. 16, in a paving rock quarry in the Piedmont district of Oakland, Cal., is reported to have buried the three powdermen, preparing the blast, under a thousand tons of rock. It is supposed that the men, who were experienced, became careless and tamped the charge with a steel drill butt.

A FIRE swept the business district of Decatur, Ill., on Aug. 22, from midnight to sunset, causing a loss of about $1,000,000. The local fire department was unable to cope with the conflagration and help was sent from Springfield and Bloomington. On account of a recent drought there was a scarcity of water and lack of pressure. After the fire it was necessary to cut off the supply from the residence districts for several hours to allow the reservoirs to fill.

IN A TROLLEY-CAR WRECK at Pittsburg, Aug. 21, one woman was killed and nine passengers were hurt. The car left the tracks on a steep incline of the West View and Bellevue line and turned over.

A controller blew out on a street car in Youngstown, Ohio, Aug. 19, causing a panic among the passengers. One woman jumped while the car was under way and broke her neck. Several other female passengers who jumped were severely bruised.

A 40-FT. FALL was taken by a passenger train on the Great Northern Ry., Aug. 22, near Grand Forks, N. Dak., without killing or fatally injuring a person, though the train was totally wrecked. The train is reported to have been proceeding at ordinary speed near the small mining town of Darts when it ran into a brush fire about a wooden bridge. The engineman was unable to see that the bridge was burning and ran onto it.

A RAILWAY TRAIN STRUCK A WAGON Aug. 15 at an unguarded crossing ten miles north of Kennett, Mo., on the St. Louis & San Francisco R. R. The five occupants of the wagon, who were all members of the same family, were killed.

A locomotive attached to a Pennsylvania R. R. train at Youngstown, Ohio, on Aug. 21, left the rails at a sharp curve in the railroad yards and overturned, killing the engineer.

A locked switch in the yards of the Central Vermont R. R. at Brattleboro, Vt., was opened and the signal light extinguished early in the morning of Aug. 21, causing the "White Mountain Express" from New York to collide with a freight. As the express was traveling at slow speed there were no fatalities or serious injuries. The locomotives were badly smashed. This is reported to be the second attempt to wreck trains at this point.

THE ARKANSAS RIVER in Colorado is reported to have risen over 20 ft. in the Royal Gorge on Aug. 18 and to have washed out the tracks of the Denver & Rio Grande and the Colorado Midland railways, stopping the heavy tourist traffic of the season at Pueblo, Salida and Grand Junction for nearly two days. It is expected that it will be several days yet before traffic is fully resumed. The loss is placed at $250,000.

FIRE IN A TUNNEL UNDER CONSTRUCTION at Lynchburg, Va., on Aug. 11, did considerable damage. The Southern Ry. is building a tunnel at Lynchburg, which was nearly completed. The timbering caught fire, and some 300 to 400 ft. in length of tunnel was damaged. To check and extinguish the fire the ends of the tunnel were closed and steam was blown in, but the success of this proceeding is not yet known. The destruction of the timbering caused some caving of the overlying ground, damaging buildings on the surface. The tunnel is about a quarter mile long, and is in part rock.

THE "MAURETANIA," giant liner of the Cunard Line, again broke the transatlantic record over the short course on the trip ending at New York City Aug. 19. The new record is 4 days, 14 hrs., 38 min. The average speed was 25.15 knots, assuming that the course was 2,783 miles from Daunt's Rock to the Sandy Hook lightship. The best day's run was on Aug. 16, 655 miles at an average of 27.3 knots. The average speed for the whole trip is not a record, as on the trip ending June 21, over the long course, a figure of 25.88 knots was established. On April 20 she is reported to have covered 200 miles at 29 knots.

A GRAND AEROPLANE MEET has been in progress since Aug. 22, at Rheims, France, and at which some 40 flying machines are assembled, including all the successful types. America is represented by Mr. Glen H. Curtiss with a single small biplane flyer somewhat on the lines of the machines of the Wright brothers. Attempts will be made during the meet to establish records for speed, endurance and cross-country flights. Mr. Curtiss established a speed record of 6¾ miles in 8 min. 32⅘ sec. on Aug. 23, but it was promptly broken on Aug. 24 by Mr. Louis Bleriot, who covered the distance in 8 min. 4⅘ sec. The Wright brothers are not present at the meet, but there are several machines on the ground built under their patents. The impressions of technical observers, as reported, indicate that the Wright flyers are the best all-around machines there. With the sky full of flitting gliders there are spectacular and thrilling performances enough to delight the Parisian crowds which come by thousands.

THE SECOND ARCTIC AIRSHIP trip of Mr. Walter Wellman was attempted Aug. 15, from Spitsbergen, in his endeavor to reach the North Pole. The dirigible balloon used is the second largest airship in the world, being exceeded only by Count Zeppelin's. It was to carry 6,000 lbs. of fuel, provisions, etc., and four persons. A huge drag-tail was used with the balloon to steady it. This was made of leather, covered with steel scales, and carried additional provisions. After the airship had gone about 32 miles northward on its trip the drag tail broke and the balloon shot up into the air. Gas was let out and propellers were used to cause the machine to return against a strong wind. The engines gave out and the airship was towed back by boats. As the starting place was reached a heavy wind tore the balloon from its moorings and badly damaged it. No further attempt can be made this season, but Mr. Wellman has announced preparations for an attempt next year.

THE LARGEST BATTLESHIPS IN THE WORLD are soon to be placed under contract by the United States Government. Bids on these two vessels, the "Arkansas" and the "Wyoming," were opened Aug. 18, and it is expected that the lettings will soon be announced. Since the design of the British "Dreadnought" started the navies of the world in the construction of "all big gun" battleships the United States has increased the size and gun capacity of each new battleship, but not until these two latest vessels has it passed the records of foreign navies. The "Arkansas" and the "Wyoming," sister ships, are to have a length of 545 ft., a beam of 92 ft. and a draft of 29 ft. They will be of 26,000 tons displacement, and are to be provided with 33,000 HP., capable of giving a speed of 21 knots. The armament consists of twelve 12-in. guns, capable of being fired in broadside, sixteen 5-in. guns and a battery of smaller pieces. The armor is 11 ins. thick in belt and barbettes and 8 ins. on the sides. Provision will be made for a crew of 1,100 officers and men.

The lowest bid submitted was $4,475,000 for one of the vessels. According to the law, the contract for the two battleships cannot be let to the same firm.

AUTOMOBILE ACCIDENTS IN CHICAGO, Ill., during the first seven months of 1909 killed 51 persons and injured 1,018 others. These figures are taken from data compiled by Mr. Horace H. Elliott, Superintendent of the Chicago bureau of police records and they include all accidents reported by the police in which automobiles were involved. Careless and incompetent chauffeurs are held responsible for the majority of the accidents.

THE SAYBROOK-LYME CONNECTICUT RIVER Bridge Commission has appointed Mr. Edward W. Bush, M. Am. Soc. C. E., to the position of Chief Engineer in charge of the construction of the new bridge across the Connecticut River, between Old Lyme and Old Saybrook, Conn. An office has been opened near the site of the bridge in Saybrook where work will be begun at once on the preparation of plans, etc. The bridge is to be the property of the State of Connecticut, a bond issue of $500,000 having been authorized for its construction, and toll will be charged for the first 20 years after it is completed. The bridge will cross the Connecticut River near its mouth and will have a length of about 2,000 ft. It will contain a draw span and will carry a single trolley track. At present two rather primitive ferries provide the only means for vehicular travel across the lower 30 miles of the Connecticut River.

A NEW ELECTRIC RAILWAY MOTOR has been brought out by Brown, Boveri et cie., of Baden, Switzerland. It is known as the "Deri type" and is a single-phase repulsion motor with a distributed single-phase field winding but with twice as many brushes on the commutator as have the ordinary types. Thus a two pole design would have four brushes, short circuited in pairs. One pair is fixed in line with the field magnetism and the other pair is shifted to vary the torque and to control the motor. With constant voltage at the primary (field) leads the motor has the characteristics of a direct-current series motor, for each position of the movable brushes. That is, the current decreases with an increase of speed and the torque decreases with the square of the current drop. Torque, speed and current relations are varied through a wide range by merely shifting the brushes. Thus the acceleration is very gradual and at highly efficient motor performance.

FOURTRACKING BETWEEN NEW YORK AND Pittsburg on the Pennsylvania R. R. main line is nearly complete, only a few short stretches of double-track and three-track line remaining. A project for improving one of these sections, at Greensburg, Pa., is about to be put under contract. At this point there is to be a grade reduction, removal of a tunnel and grade-crossings, construction of a new station, etc., so that the stretch of about one mile of improvement will cost about a million dollars.

Plans for extensive line improvements on the Pennsylvania Lines West of Pittsburg and Erie are also being drawn. Extending the double track, reducing grades, etc., is to be done at a cost of about seven millions.

A CARLOAD OF PIG IRON produced in the electric furnaces of the Noble Electric Steel Co., at Heroult-on-the-Pitt in Shasta County, California, is reported to have been placed on the Pacific Coast at a total cost, from ore to customer, less than that of pig iron smelted from coal and freighted in. The capacity of this plant is now 4,500 tons per annum. The pig is reported free from sulphur and adapted to making high-grade steel.

PENNSYLVANIA COKE.—This state produced, in 1908, 59.58% of the coke output of the United States. In 1907 it produced 65.02%. The tonnage figures of the state for 1908 and 1907 were, respectively, 15,511,634 and 26,513,214. The figures for the whole country for these years were 26,033,518 and 40,779,564. The years 1908 and 1907, however, were years of plenty in the coal-mining and coke-producing industries and can hardly be considered representative of the normal production. If, however, the production of Pennsylvania in 1908 is compared with the average of the eight preceding years, it is noted that the production still shows a decrease of 2,597,188 short tons, or 14.3%. The production in 1908 was the smallest since 1904.

The average price per ton obtained for coke in Pennsylvania in 1908 was $2.10, as compared with $2.55 in 1907, $2.35 in 1906, and $2.05 in 1905. The only reason to be assigned for the excess in the 1908 price over that of 1905 is the fact that operators were able through contracts to maintain prices and thus prevent entire demoralization, and also the fact that a large proportion of the coke produced in Pennsylvania is not placed on the market but is used by the producers themselves or by allied interests, and the value placed upon it is purely arbitrary. The total value of the coke produced in Pennsylvania in 1908 was $32,569,621, against $67,638,024 in 1907, a decrease of 51.8%. This decrease in the value of the production in 1908 was greater than the value of the entire coke output of Pennsylvania in 1904.

The coal consumed in making coke in 1908 amounted to 23,215,964 short tons, or 19.81% the total production of bituminous coal. In 1907 this figure was 26.4%.

indicating that the decrease in the demand for coke by the iron furnaces was in greater proportion than that in the demand for coal from other consumers of fuel.

The number of coke-making establishments in 1908 was 252, one less than in 1907, though the total number of ovens in the state increased from 51,364 to 52,606. Of these establishments 44 were idle, and 3,616 ovens were out of blast throughout the year.—From an advance report of the U. S. Geological Survey.

VIRGINIA COAL IN 1908.—Notwithstanding the important developments in the Black Mountain district of Lee county, which resulted in an increased production of coal in that county in 1908, the total production of the state in 1908 decreased from 4,710,895 short tons, valued at $4,807,533, in 1907, to 4,259,042 short tons, valued at $3,868,524, in 1908, a decrease of 9.59% in quantity and of 19.54% in value. Wise county, the most important coal-producing county, showed a decrease of 586,972 short tons in 1908, while Tazewell county's production fell off 136,520 short tons. Practically all of the decrease in the 1908 production was in the quantity of coal made into coke.

With the completion of the Norfolk and Western Ry., in 1882, the coal fields in the southwestern part of the state, which belong to the Appalachian system, were opened. A portion of the famous Pocahontas district is included within Tazewell county, and the construction of the Clinch Valley branch of the Norfolk & Western, in 1892, opened valuable coal lands in Wise county, which has since become the most important producing district in the state. The development of the Black Mountain field in Lee county, after the completion of railroad connections from Pennington Gap to Appalachia, was begun in 1905 and a small production was reported in 1906. In 1907 the output of this country amounted to nearly 200,000 tons, and in 1908 to more than 460,000 tons. Further development of this district is expected. The total area of coal lands in the state is some 1,900 square miles and the original contents were approximately 22,500,000,000 short tons. At the close of 1908 61,488,194 short tons had been mined, equivalent to an exhaustion of 92,000,000 short tons or 0.4% of the original contents.—From report of E. W. Parker, in "Mineral Resources of the United States, 1908."

AN EMERGENCY RESPIRATOR for use in mines is reported to have been invented by Mr. Clarence Hall, of the U. S. Geological Survey. The "respirator" consists of two cans, through one of which is drawn the air which is to enter the lungs. This air is here enriched with oxygen, generated by dropping water upon sodium peroxide. The exhaled breath passes through the other can, containing lye to absorb the carbon dioxide.

ELECTRIC TRAMWAYS OF PARIS.—The light surface railways were originally horse-car lines, quite similar in character to American lines of 30 years ago. They have been gradually converted by the adoption of electric, steam, and compressed-air motors until only a few of the horse-car lines remain in service. The system as it existed at the close of 1904, the latest year for which complete statistics are available, was practically in the hands of five large companies, with mileage, service, and results as follows:

(1) General Parisian Co., with 14 lines, making 4,065 trips per day, 1,487,137 trips per year. Total number of passengers carried, 70,475,373, an average of 47 per trip.

(2) Western Tramway Co., five lines, making 752 trips per day, 275,774 per year. Total number of passengers carried, 6,663,211, an average of 23 per trip.

(3) Electric Tramway Co. of The Left Bank of The River Seine, two lines (Montreuil-Boulogne-sur-Seine and Boulogne-sur-Seine-Vincennes), making 504 trips per day, 184,617 per year. Total number of passengers carried, 10,707,170, an average of 57 per trip.

(4) Eastern Tramway Co., 15 lines, making 2,016 trips per day, 737,850 per year. Total number of passengers carried, 43,235,834.

(5) The Company of Tramways of Paris and of The Department of The Seine. This is an important group of lines, 36 in all, which radiate from the city to St. Denis, Aubervilliers, Courbevoie, and other towns and villages in the department. They made during the year 1,248,626 trips, an average of 3,442 per day, and carried 58,969,398 passengers. The total mileage of all the tramways in Paris during the year 1904 was 19,873 kilometers (12,348 miles), and the aggregate receipts were 26,666,704 francs, or $5,146,538, an average of 34 cts. per car-mile.

There are thus 62 lines of tramways operated, and 190,050,986 passengers carried in an average year. Many of the Paris tramway cars are, like the omnibuses, double decked, the fare within the city walls being generally 6 cts. for the inside and 3 cts. for the upper deck. Some of the cars are of the American pattern. Certain routes divided into sections of about two miles, for which 2 cts. per section, or 3 cts. the whole distance, are the fares charged. For 6 cts. a transfer ticket is given which enables a passenger to take another car or bus and thus continue his route to a district not covered by the first vehicle. The several lines vary in respect to the maximum distance to which a passenger is carried for one fare. Most lines run first and second class compartments or cars, and the fares are usually in the proportion of 6 cts. for first (inside) and 3 cts. for second class (outside). There is no one central point of tramway service in Paris, such as exists in most American cities. The cars start from several different focal points and run as is explained in the list of companies above.

Cars do not stop on signal but only at regular stations, which are fixed by the prefect of police at convenient distances. The concessions granted to the companies prescribe the minimum number of daily trips, the capacity of cars, the limitations of speed, the duration of the charter, and the price of the fares. All concessions for lines which pass beyond the walls of Paris are granted by the State. It is difficult to specify just what tax or contribution the various lines pay to the municipality. Each company has a separate charter, in which special conditions are granted and certain obligations imposed, but the average levy is estimated to be about 5 francs (96 cts.) per car per day. The municipal budget for 1905 shows that the city received from public conveyances a revenue of 11,243,370 francs ($2,170,935); but as this item includes cabs and omnibuses as well as street-car lines, it is impossible to ascertain from the statistics how much of the entire sum was derived from street-car companies. The other taxes are not large, and are in the form of rental for the occupation of the streets. The Company of Tramways of Paris and of The Department of The Seine, with 36 separate lines and branches, paid only 10,005 francs ($1,935) during the year. This will indicate the very moderate basis on which taxes of that class are imposed.—From a report by Consul-General Frank H. Mason.

Personals.

Mr. Henry J. Kesner, formerly with the Minneapolis Steel Co., is now an instructor in the Department of Civil Engineering of the University of California.

Mr. H. E. M. Kensit, Assoc. Am. Inst. E. E., Chief Assistant of Smith, Kerry & Chace, Consulting Engineers, of Toronto, Ont., has removed to Calgary, Alta., where this firm has opened an office at 68 McDougall Block.

Messrs. C. W. Cromwell and R. H. Willcomb have resigned from the Engineering Department of the Boston & Montana Consolidated Mining Co., at Great Falls, Mont., to open a general engineering office at St. Maries, Idaho.

Mr. Thomas B. Sears, Assoc. M. Am. Soc. C. E., formerly Associate Professor of Civil Engineering in the University of Nebraska, has become Associate Professor of Railway Engineering at the University of California, at Berkeley.

Mr. C. W. Swearingen and Mr. Carroll B. McCullah have opened offices as civil and consulting engineers in the Dunn Block, Great Falls, Mont. Mr. Swearingen was formerly City Engineer of Great Falls and Mr. McCullah was Assistant City Engineer.

Mr. Preston K. Yates, M. Am. Soc. C. E., has resigned his position as Secretary of the W. L. Crow Construction Co. to become Chief Engineer of the Tomkins Cove Stone Co. Mr. Yates has charge of the design and construction of the new plant to be erected at Tomkins Cove, N. Y.

Mr. W. N. Patten, Engineering Manager of the Stone & Webster Engineering Corporation, of Boston, Mass., has entered the construction department of the concern. He is succeeded as Engineering Manager by Mr. Frederick N. Bushnell, M. Am. Soc. M. E. Mr. Bushnell joined the staff of Stone & Webster in February, 1907, taking charge of the construction of the Lincoln, Harvard and Charlestown power stations of the Boston Elevated Ry. This work consisted in substantially enlarging the structures of the three original stations and installing 20,000 HP. of new generating capacity with boilers and all other auxiliaries. Previously, Mr. Bushnell was Chief Engineer of the Rhode Island Company, in charge of design and construction of stations, barns, bridges, tracks and also of the operation of power stations.

Obituary.

Robert Reid, of Ottawa, member of the Canadian Transcontinental Railway Commission, died suddenly at Ogunquit, Me., on Aug. 22.

J. B. Stetson, President of the California Street Cable Ry. Co., died at San Francisco on Aug. 21. He was identified with interests promoting light railways in Central California.

Walter W. Ewell, ex-Commissioner of Public Works, of Quincy, Mass., died in Quincy on Aug. 22. He was born in Quincy, in 1849 and was interested in manufacturing and mercantile concerns. He became Commissioner of Public Works in 1891 and held that place for three years. In 1898 he became Superintendent of Water-Works, which office he filled for one year.

John P. Brown, a pioneer railway contractor, died in Atchison, Kan., on Aug. 23 at the age of 80 years. He came to America from Ireland as a boy and worked with surveying parties of the Pennsylvania R. R., near Pittsburg. In 1853, it is reported, he took a contract with the Baltimore & Ohio Co., and later built the St. Louis, Iron Mountain & Southern Ry., between St. Louis and Pilot Knob, Mo. In 1858 he settled in Atchison, Kan., taking contracts for the construction portions of the Central Branch Ry., of the Missouri Pacific system.

Henry B. Richardson, M. Am. Soc. C. E., member of the Mississippi River Commission, died at New Orleans on Aug. 21. He was born in Winthrop, Me., Aug. 23, 1837, and was educated in the schools of Portland, Me. From 1857 on he worked in civil engineers' offices in Portland, Milwaukee, Chicago, Boston and in Louisiana. In 1861 he became a private in the Sixth Louisiana Infantry. He was subsequently promoted to the line and transferred to the Engineering Corps of the Confederate States Provincial Army of Northern Virginia. He was captured as a prisoner of war and confined at Johnson's Island Military Prison. He married Anna H. Farrar, of St. Joseph, La., in 1867. From 1877 to 1904 he was a member of the Louisiana State Board of Engineers and was Chief State Engineer from 1880 to 1904.

Adolphus A. Knudson, M. Am. Inst. E. E., Consulting Electrical Engineer of New York City, died suddenly at Meadville, Pa., on Aug. 13. Mr. Knudson was a familiar figure at meetings of electrical engineers about New York City and was one of the older members of the American Institute, becoming an Associate in 1887. He was born in Southport, Conn., Dec. 15, 1845, of Norwegian parents. His father was a sea captain but the son gave up that life to study electricity. He was not college educated and received his technical training in the schools of experience. For considerable time he was engaged in telegraph construction and developed no little inventive ability. He had been connected with the Western Union Telegraph Co., and with stock-ticker concerns in New York. While with one of these companies he brought out a new design of ticker. For many years past he had been devoting himself to the study of electrolysis by stray railway currents and was one of the pioneer investigators in that field. He had gone to Meadville early in the week of his death to make an expert examination of the water-supply pipes of that place, where electrolytic troubles were feared. His survey was well under way and it is supposed that his sudden death was due, particularly at least, to the hot weather during which he worked. Mr. Knudson is survived by a widow.

Engineering Societies.

COMING MEETINGS.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Aug. 31-Sept. 2. Annual meeting at Briarcliff Manor, N. Y. Secy., D. L. Huntington, Spokane, Wash.

TRAVELING ENGINEERS' ASSOCIATION.
Sept.7-10. Annual convention at Denver, Colo. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 8-10. Annual convention at New York City. Secy., Willard Kent, 715 Tremont Temple, Boston, Mass.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 14-16. Annual convention at Atlantic City, N. J. Secy., Frank P. Foster, Corning, N. Y.

MICHIGAN GAS ASSOCIATION.
Sept. 14-17. Annual meeting on board steamer sailing from Detroit, Mich. Secy., A. P. Ewing, Gas Office Bldg., Detroit, Mich.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION.
Sept. 14-17. Annual convention at Washington, D. C. Secy., Walter E. Emery, Peoria & Pekin Union Ry., Peoria, Ill.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 14-17. Annual convention at Niagara Falls, N. Y. Secy., A. P. Dane, Boston & Maine R. R., Reading, Mass.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Sept. 16-Oct. 12. Annual convention and excursion as special train starting at Chicago, Ill. Secy., R. W. Raymond, 29 W. 39th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
Sept. 25-27. Annual convention at New York City. Secy., P. S. Millar, 25 W. 39th St., New York City.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.
Oct. 4-8. Annual convention at Denver, Colo. Secy., Bernard V. Swenson, 29 W. 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 12-14. Annual convention at Louisville, Ky. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 19. Annual convention at Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine R. R., Concord, N. H.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 19-22. Annual convention at Richmond, Va. Secy., Chas. O. Probst, Columbus, Ohio.

AMERICAN GAS INSTITUTE.
Oct. 20. Annual meeting at Detroit, Mich. Secy., A. B. Beadle, 29 W. 39th St., New York City.

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